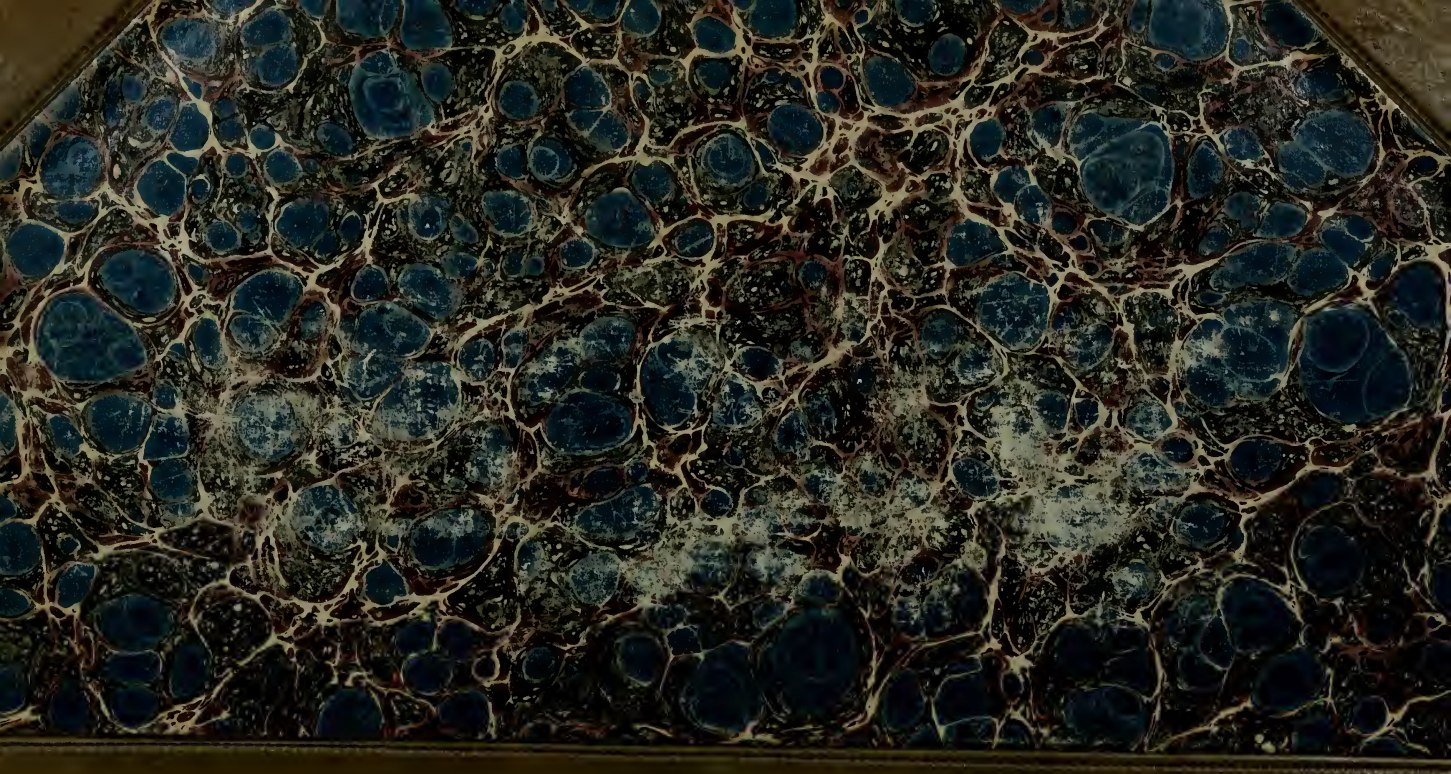
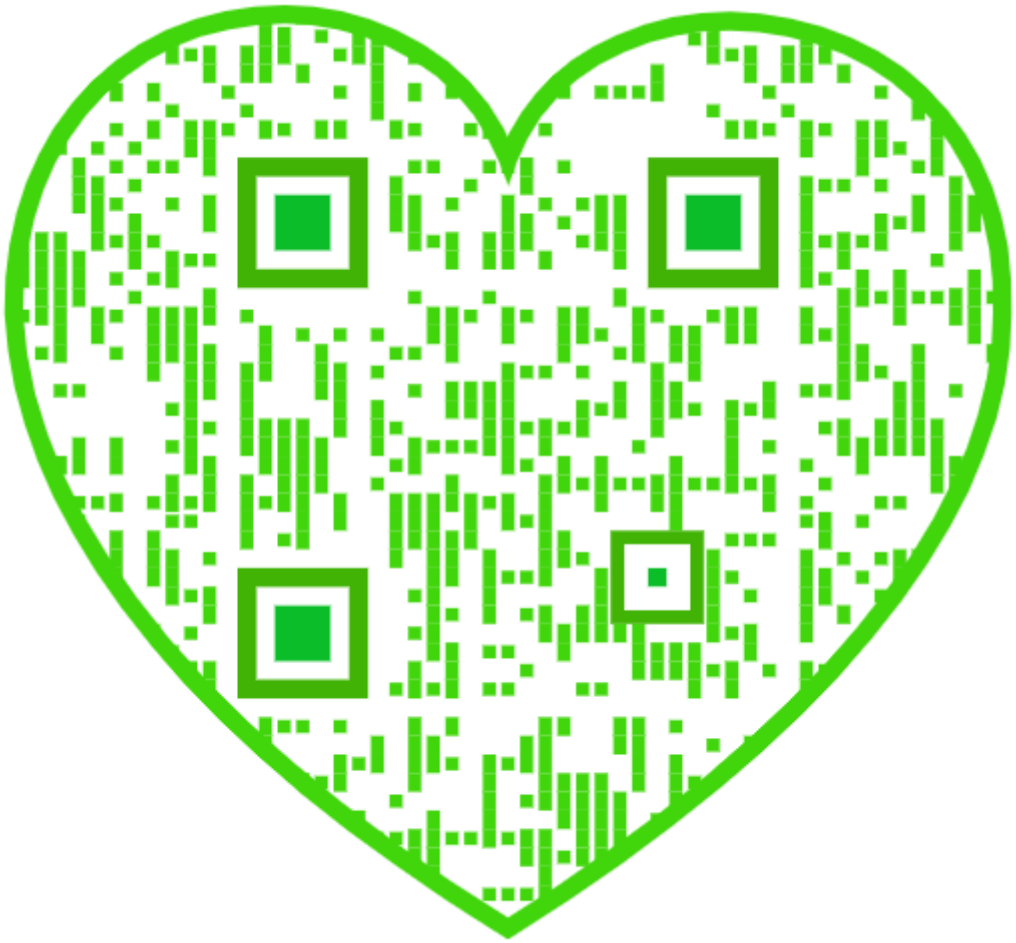
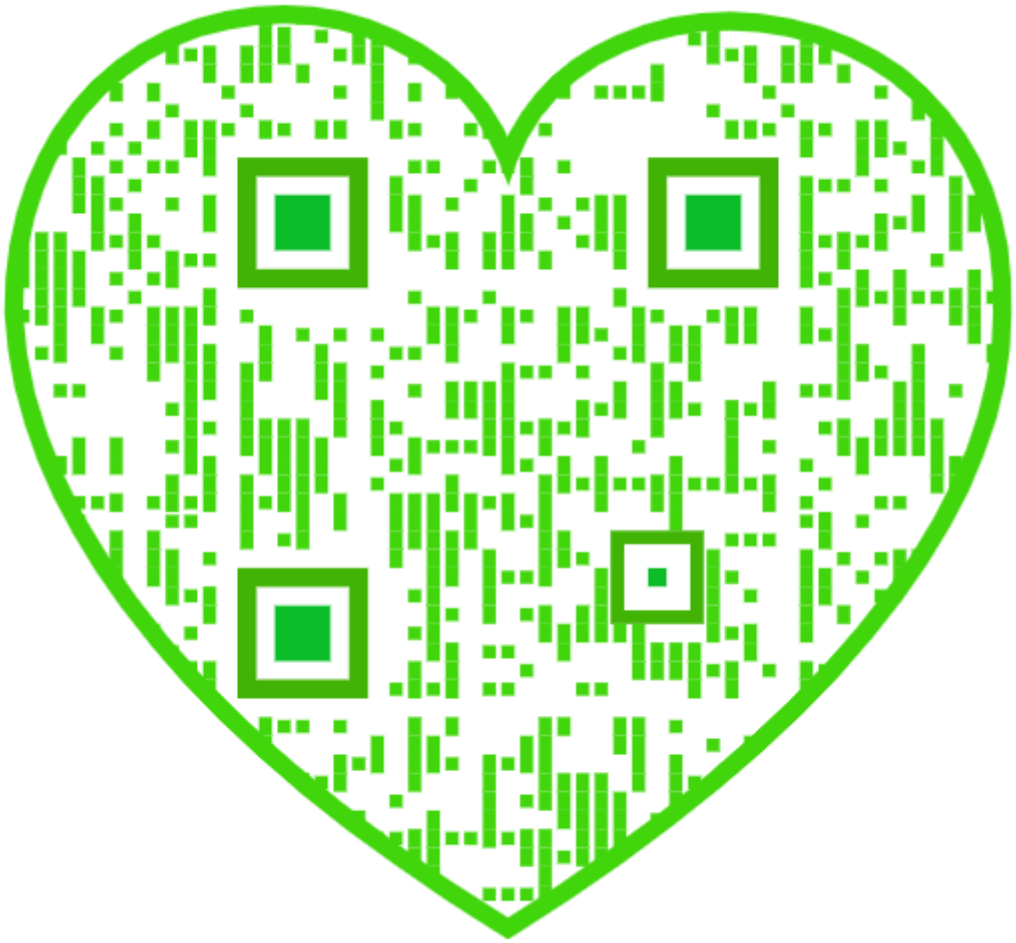






THE

UTILISATION OF SEWAGE,

AND A

DESCRIPTION

OF THE

"ABC" PROCESS.

REPRINTED, BY PERMISSION,

FROM "The Standard" NEWSPAPER.

LONDON:

PRINTED BY E. NEWMAN, 9, DEVONSHIRE STREET, BISHOPSGATE.

1871.

CONTENTS.

	PAGE
General Review	5
Crossness Works described	9
Results from Native Guano in Sussex	17
Bolton Works described	23
Leeds Works described	29
History of the "A B C" Process at Leamington	33
Results from Native Guano in Warwickshire	36
Advantages of the "A B C" Process as compared with Irrigation	46
Chemical Value of Native Guano	49
Index	55

The Directors of the Native Guano Company (Limited), observing that the following articles, which appeared in the *Standard* during the past and present month, contained a good description of their "A B C" Works and process, applied for permission to republish the same, a request which was readily granted.

It may be right to explain that the information laid before the public in these articles was collected by a gentleman on the staff of the *Standard*, deputed by the conductors of that journal, on public grounds, to institute a special inquiry into the subject referred to, now universally felt to be one of great national importance. The valuable evidence, gained directly from the farmers of Warwickshire and Sussex, as to the beneficial results accruing from the use of Native Guano, will be of particular interest to the shareholders of the Company, besides affording information of a useful character to all who are desirous of seeing the sewage of towns made available for agricultural purposes.

(Signed)

C. RAWSON,

General Manager of

The Native Guano Company.

1, *St. Swithin's Lane, London,*
16*th November*, 1871.

UIUC

THE UTILISATION OF SEWAGE.

(Leading Article, from the 'Standard' of November 6, 1871.*)*

The importance of the subject—not only locally but nationally—will be held to justify the degree of prominence we have long given to the question of sewage utilisation. At the present time there are writers and speakers who argue as if the whole controversy were about to be finally set at rest, and as if all the difficulties were virtually at an end. By one bold legislative stroke—something as sweeping and irresistible as a Royal Warrant—it is expected that every town will be interdicted from discharging its sewage into the streams and rivers, and that as a consequence the sewage will be applied to the land. That sewage ought not to go into a river or any kind of water-course is clear. That sewage would be highly serviceable as a manure is equally certain. But, for all that, there is an obstacle in the way which is exceedingly formidable. Strange to say, the farmer is that obstacle. Speaking of him as we generally find him, he does not care for sewage; he does not ask for it; he does not come forward to buy it. The agriculturist knows very well that if he is to make use of sewage; he must prepare his farm for its reception. To avail himself of this agent he must lay out his land in a particular way, he must drain it effectually, and he must have a system of pipes or sewage-gutters ranging round his farm—all of which necessitates expense. Why should he do it? His fields are not sterile. Peruvian guano is not yet exhausted. Artificial manures are abundant, and apparently answer his purpose well enough. Again, if the farmers are to take the sewage of towns, they must take it always. In this case the demand must be brought up to the supply, which is in direct contradiction to one of the leading canons of modern political economy. The towns might insist, as part of the bargain, that if the farmer took the sewage at all he should take it always. But let the bargain

be shaped as it may, the farmer cannot be compelled to enter into it, and for the present his choice seems to run in another direction. He is, indeed, gravely warned by Baron Liebig that unless the refuse matter of towns is returned to the land the country must ultimately become barren. Peruvian guano may arrest the catastrophe, but this resource is an uncertain one. It may be intercepted by war, and will certainly be exhausted by time. If the material which is taken from the land does not go back to it, the soil will at last become exhausted, and the once fruitful fields "will be turned into a desert waste like the Roman Campagna." It is not a little startling to read such words as these:—"The sewers of the immense metropolis of the Ancient World engulfed in the course of centuries the prosperity of the Roman peasant, and when the fields of the latter would no longer yield the means of feeding her population, these same sewers devoured the wealth of Sicily, Sardinia, and the fertile lands on the coast of Africa."

With a sort of sanitary crisis impending over the whole nation, and one of an agricultural character looming in the distance, we cannot afford to disregard any facts which promise to open a way out of the dilemma. Most persons who know anything of this subject are aware that a Company exists, having for its object the carrying out of what is called the "A B C" process for the treatment of sewage. By means of alum, or sulphate of alumina, together with blood, clay and charcoal, a compound is formed which, on being mixed with a small quantity of water and a considerable volume of sewage, has the effect of purifying the latter and throwing down a deposit which is said to possess valuable manurial properties. To make the deposited matter portable, it is dried and is subsequently sold under the attractive title of "Native Guano." The Rivers Pollution Commissioners gave some attention to this process about three years back and at subsequent periods. Rather more than a year ago the Commissioners published a Report bearing solely on the "A B C" process, a circumstance which might be held to indicate no ordinary importance as attaching to the subject. But the Report was utterly condemnatory, and we can only suppose that if the Commissioners had been substantially correct in their conclusions, the Company working the "A B C" patent must have been speedily extinguished. Nevertheless the enterprise still goes on, and is more vigorous and active than ever. It is obvious that the commercial success of this undertaking is essentially dependent on the actual value of the "native guano" as a manure. Feeling the great importance of correct information on this point, we have caused inquiries to be made in various parts of England to ascertain the agricultural results accruing from the use of

the new fertiliser. The facts thus discovered, and various incidental circumstances, have been narrated in our columns in a series of articles which have just come to a conclusion, and which we trust have thrown considerable light on a subject which has been keenly controverted.

That the value of the "A B C" manure should be disputed by Chemistry, but affirmed by Agriculture, is a paradox we need not stay to explain, though the writer of the articles has offered some suggestions for that purpose. The Rivers Pollution Commissioners have valued the "native guano" at a few shillings per ton, but the Warwickshire farmers are eager to buy it at £3 10s. These farmers cannot be deceived, neither could our correspondent be misled when he walked over the ground and saw the crops. Decided testimony was given by numerous agriculturists as to the excellence of the manure, and it cannot be supposed that all this is an illusion. The explanation in which some indulge, that the native guano is surreptitiously "fortified," has the narrowest possible basis to stand upon. Such a scheme might be supposed to answer a temporary purpose, but could not be carried out for a series of years, and in connection with large transactions. Besides, if the manure be fortified, analysis would reveal the manœuvre, instead of showing that the quality is deficient.

Some time ago a learned professor, for whom we entertain great respect, denounced the "A B C" process as "a juggle." The phrase was unworthy of his lips, and although the expression was doubtless provoked by a particular incident, that incident was isolated in its character, and ought not to have prejudiced the whole enterprise. Scientific evidence now shows that the Rivers Pollution Commissioners were themselves grievously mistaken on one important point. They were positive that the "A B C" process could not affect the chloride of sodium contained in the sewage. Hence when they found that the effluent water from the "A B C" tanks at Leamington showed a great reduction in the contained chlorine, instead of giving the credit of the result to the "A B C" process, they boldly turned round and charged the Company with cunningly diluting the "effluent." But the reduction of chlorine was so great that to account for it the Commissioners were obliged to suppose that the "true effluent sewage" had undergone dilution to an extent which, in one instance, was as much as four times the proper volume. One would have supposed that if the sewage of a population so great as that of Leamington had suddenly been increased fourfold by some species of "juggle," the keen eyes of a Royal Commissioner would have discerned the fact at once, without the aid of a chemical analysis. Moreover, if the sewage had been

thus diluted with "clear river water," as suggested, the temperature of the effluent must have been lowered. It is stated that the Royal Commissioners did take the temperatures of the sewage, the effluent and the river. If so, why were not these data given in the Report, as most essential to a right exposition of the subject? We now learn that the "A B C" compound does really affect the chlorine, and that, at least in one instance, it has produced an effluent water superior to that of the Lodge Farm at Barking, where sewage irrigation is skilfully practised, and with the advantage of not being obliged to take the sewage continuously.

Not to enlarge further on a topic which well admits of it, we would observe that the "A B C" process, which at one time was thought to be utterly discredited, has gained that point which sewage irrigation unfortunately has not yet reached—it has made eager customers of the farmers, and it has commanded a premium of several hundreds per cent. in the share market. It has not had the years in which to perfect itself which sewage irrigation has enjoyed, nor the official favour which that system has continuously received. There is no reason to despair of irrigation, and possibly the two systems may be combined, but certainly it would be a great mistake to pass by a process like that to which we have now referred, which appears to accomplish its purpose with a minimum of trouble and expense. If there be any defect, it is the loss of the water with which the sewage is mingled. The effluent need not be lost, but stored for future use on the farms, a provision which is looked forward to as the next great step in high farming. Mere water alone is a great fertiliser, and it is pretty certain that we are already throwing far too much of it away. But while it is easy to get rid of water, it is not so easy to get rid of sewage.

THE CROSSNESS SEWAGE EXPERIMENT.

(*From the 'Standard' of September* 2, 1871.)

In the course of a few weeks an experiment will commence at Crossness, on the result of which very important consequences may be said to depend. As many of our readers are aware, Crossness is the spot where the southern sewage of the metropolis is pumped from the great outfall sewer into a covered reservoir, prior to the discharge of the sewage at a proper period of the tide into the river. "Crossness" appears to be simply the designation of a projecting part of the southern shore of the Thames, intervening between the Plumstead and Erith marshes. Descending the river, we find the Southern Main-drainage Works, or pumping-station, situated a little below Crossness point, but still very near it, the distance being about a third of a mile. It is a lonely spot, some three miles further down the river than Woolwich, and a mile and a half from the nearest railway station (Abbey-wood), on the North Kent line. The country intervening between the railway and the river is a huge marsh, only preserved from inundation by an embankment. As mentioned by Mr. Bazalgette, in his account of the main drainage of London, these marshes originally formed part of the Thames, being first reclaimed in the reign of Edward I. by the monks of Lesnes Abbey. In the reign of Henry VIII., 2000 acres were flooded by the river bursting its banks, and were not recovered until the reign of James I. A similar disaster very nearly occurred in 1864, on the occasion of the explosion of Messrs. Hall's powder magazine. The pumping station is secured against the danger of inundation by being placed partly on the embankment, and partly on an artificial plateau which covers the reservoir. The area of the sewage reservoir is six acres and a half. The plateau, laid out with grass and gravelled paths, and a few shrubs and flowers, is a very pleasant-looking spot. Twenty-one cottages, of somewhat villa-like appearance, fringe the plateau, while on the river side appear the grand proportions of the engine-house, where four colossal engines, with a collective power of 500 horses, are heaving up the sewage from the level of the sewer into the great reservoir. The daily quantity of sewage now discharging at Crossness is, on the average, about 50,000,000 gallons, or more than 223,000 tons. But the engines are capable of lifting 280 tons in a minute, or nearly double the average flow. The lift, we may observe, varies from ten to thirty feet,

according to the relative levels of the water in the sewer and in the reservoir. Though of lesser magnitude than the Abbey Mills pumping-station on the northern side, the Crossness works are quite sufficient to excite the admiration of the visitor.

The idea of dealing with this immense mass of sewage by a process of chemical precipitation appears at the outset to be little better than chimerical. Yet the idea is entertained in certain quarters, and the subject is being approached in a practical and decided manner. Not only is it thought that the southern sewage could thus be dealt with—deprived of its manurial ingredients as it passes on, and the effluent water allowed to flow day by day into the river, but a like mode of dealing with the northern sewage is held to be quite feasible, and certain to return an abundant profit. The mere water supply of London is equal to something like 16,000,000 cubic feet per day. To this we must add a proportion of the rainfall, equal to at least 7,000,000 cubic feet per day, making a total of 23,000,000 cubic feet, or 143,750,000 gallons. What this means will be better understood by saying that such a quantity would cover 176 acres to a depth of three feet. Or it would fill a canal fifty feet wide, ten feet deep, and more than eight miles and a half in length. Let us imagine this bulk of water converted into what we call "sewage" by the admission into its volume of the excreta of a population equal to three millions and a quarter. The admixture includes every kind of liquid refuse, and the result is a flowing mass, repulsive to the sight and offensive to the sense of smell. The fluid flows on at a rate which would empty the canal in twenty-four hours, were it not that the supply is perpetual. Let us further conceive of some modern magician standing by the side of this Stygian stream, waving his wand, and so controlling the nature of the fluid that, while it comes to him all foul, dark and loathsome, it passes away as bright and clear as a mountain rill. The filth is transformed, first into heaps of shining gold, which fall at the magician's feet, to be distributed among mankind as dividends and as sums in aid of public rates, while further results appear in the shape of waving corn-fields and a fertile land. Such, in substance, is the task which is now contemplated, and should the experimental works at Crossness prove successful the great enterprise will not be allowed to slumber. Sewage irrigation—sound and right as it is—drags wearily along, inasmuch as towns are slow to undertake it, and farmers shrink from the trouble of introducing it. Offer a farmer a bag of manure, and he will buy it. It is an easy thing to put the dry stuff on the land and let the rains of heaven wash it in. But ask the agriculturist to perfect the drainage of his land, to lay it out in a certain way, and to adopt the necessary devices for irrigation, and we find at once how difficult it is to persuade the man to enter on such an undertaking. Yet, if the chemical process should prove a final failure, sewage irrigation is the only hope, and even if the chemical process succeeds, sewage irrigation will have its own particular claims to regard. The irrigation plan places a supply of water at the disposal of the agriculturist, and this, of itself, is an immense advantage. Even the chemical process would be all the better if supplemented on the farm by a store of water, preserved against the time of drought. Plants must drink as well as eat, and all their food is taken in a form which necessitates the presence of a fluid.

The experimental Works of the Native Guano Company now appear on the eastern side of the Crossness pumping-station. The land occupied by these new Works belongs to the Metropolitan Board, and the Company have

simply obtained permission to occupy the site for twelve months. Should the experimental Works prove a nuisance, the Company will be liable, by their agreement, to have the process at once stopped. All the risk is theirs, and the conditions are stringent. The Native Guano Company erect their buildings, and find their machinery, chemicals, working staff, &c., all at their own cost, while the whole of their operations at this spot are to be under the surveillance of the Metropolitan Board. Not only will the Board have the right to enquire into every particular as the experiment goes on, but it is a direct obligation on their part that they shall actually do so, in order that the Native Guano Company may have the benefit of an indisputable report from the Metropolitan Board, as to whether or not the Company's process is successful, both in a sanitary and commercial sense. On the part of the Company the affair is in the nature of an experiment. On the part of the Board it is in the nature of an official inquiry. The Board are to be satisfied, one way or the other, and the Native Guano Company are avowedly prepared to stand or fall by the result. Every precaution will be taken to place the results beyond dispute. Nothing can go into the place, and nothing can be taken out of it, without the knowledge of the officers of the Board. The accounts will be investigated by one of the Board's accountants, and vouchers will be required for every transaction. Mr. T. W. Keates, the consulting chemist of the Metropolitan Board, will be responsible for the chemical facts, while Mr. Houghton, the superintendent of the pumping-station, will have the oversight of the financial and mechanical details.

The *spécialité* of the Native Guano Company is already familiar to the public by the appellation of the "A B C" process. Some time ago it was the subject of an adverse report from the Rivers Pollution Commission, founded upon an investigation of the process as then carried on at Leicester and Leamington. The directors of the Native Guano Company are understood to acknowledge that the commissioners, according to the circumstances which then existed, were to a great extent justified in drawing unfavourable conclusions. The directors have been willing to profit by the official inquiry, and now express their firm belief that their undertaking is in a position to bear any amount of investigation. It would seem that the public participate to a great extent in this feeling of confidence, the Company's shares having recently experienced a remarkable rise in the market. Shares in other sewage undertakings have also risen, and we seem to be on the verge of that period which was along ago predicted in these columns, when sewage utilisation would be the subject of a mania almost equal to that which once affected railway enterprise. There can be no doubt that if the Crossness experiment succeeds, not only will the Native Guano Company become one of the financial marvels of the age, but the nation at large will feel the effect. Expectations may yet be disappointed; but if present appearances are verified with reference to the "A B C" process, the productive power of our agriculture will be immensely increased, and the mass of sewage at present wasted will be made to yield its value. To this we may add the saving of money in the purchase of foreign manure; and altogether it is impossible to deny that if present hopes are realised the result will not merely be represented by a successful speculation, but by an enormous increase in the national wealth. We need scarcely add that to augment the productiveness of the soil affords a surer source of national prosperity than the development of manufactures, and affords the best guarantee for the reduction of pauperism.

Having offered these remarks, which seem due to the character of the enterprise, we proceed to describe the manner in which the "A B C" experiment is to be carried out at Crossness. In the first place, the sewage to be operated upon, amounting to 500,000 gallons in the four-and-twenty hours, will be drawn from the "cross-cut," that is to say, the channel or culvert through which the sewage flows into the great reservoir. The quantity thus taken will therefore be the fairest possible sample of the sewage generally, and will amount to one per cent of the whole. From this point, which is some sixteen or eighteen feet below the surface of the ground, the sewage will flow through a large pipe into the sump of the pumping-engine on the Works of the "A B C" Company. This engine, made by Messrs. Appleby Brothers, performs various operations required in the process, and is a 15-horse high-pressure horizontal engine, with a stroke of two feet. The sewage being lifted to the pump-head, will flow into a cylindrical iron tank placed upright in the "mixing" room. The pipe which is to feed the tank has its entrance at the base, and has a junction at this point with a pipe which conveys the "A B C" mixture, so that the sewage and the "A B C" compound are mingled together at the moment they enter the tank. The fluids having their entrance at the bottom of the cylinder the flow is upwards, for which purpose a sufficient pressure is obtained by a simple gravitating arrangement. The tank will be always full, and the rate at which the combined fluids will pass through it will be such as to carry the stipulated allowance of sewage, being equal to very nearly six gallons per second. The quantity of "A B C" mixture added to the sewage, judging by previous experience, will be in the proportion of about one per cent., including the water in which the "A B C" ingredients are first of all dissolved. Thus 5000 gallons of the "A B C" solution will be added to the 500,000 gallons of sewage.

It may be well here to explain at once what is included in the mixing of the "A B C" compound. Ten thousand grains of raw sewage require from sixteen to eighteen grains of the "A B C" ingredients, exclusive of water. The compound comprises from two to three grains of crude sulphate of alumina, three grains of animal charcoal, ten grains of clay, and one or two grains of blood. These are mixed with eighty-two or eighty-four grains of water, making therefore a total of one hundred grains, or one per cent. of the 10,000 grains of raw sewage. The sulphate of alumina is obtained in a very cheap form. Clay is first of all dried by being placed on a surface heated from beneath by waste heat from the engine furnace. When the clay is dry and hot, it is mixed with sulphuric acid, which seizes on the alumina in the clay, and forms the sulphate. The effect, in a commercial point of view, is described as reducing the cost of the sulphate of alumina from pounds to shillings. Whether the result is equal in all respects to the sulphate of alumina for which £6 10s. per ton was paid at Leamington, and £7 10s. per ton at Hastings, we can scarcely undertake to say; but it is said to answer all the requirements of the "A B C" process, and therefore represents a substantial saving. The one or two grains of blood mentioned in the list are mixed with the ten grains of clay, this clay being distinct from that which assists in producing the sulphate of alumina. The blood is that of a living animal, coagulation being fatal to the required properties. Mixed with the clay, the blood remains moist until wanted for use. To secure these advantages, the clay is sent in tubs to the slaughter-houses. For the grinding of the clay and other chemicals, a crushing mill is fitted

up in the chemical store-room, contiguous to the mixing-room, the mill consuming rather less than the power of two horses, as indicated by the engine.

In the same room with the cylindrical tank are four "mixing pits," like shallow wells. It is proposed to keep the acids and the alkalies separate until they meet in a fifth pit or well, whence the perfect mixture is pumped up to a level which enables it to flow into the cylindrical tank with the sewage. Each mixing pit, as also the tank, has within it a stirrer or agitator, worked by the engine. A moderate agitation is found to be better than a more violent treatment of the mixture, both in the making of the "A B C" solution and in the blending of this with the sewage. In the latter instance the union is partly chemical and partly mechanical, thus accounting for results which could scarcely be expected on chemical grounds alone. This part of the process is graphically described by saying that the particles "go down arm in arm." This deposition, however, does not take place in the cylindrical tank. The operation in this tank is simply one of mixing, so as to blend the sewage and the solution. The back of the mixing-room, where the cylindrical tank is placed, abuts upon the western end of six out-door tanks, constructed of concrete, and ranged side by side. The floor of these tanks is level with the ground, the walls rising up so as to form a species of edifice about 150 feet in length. Each tank is fifty feet long by twenty feet wide, and eight feet deep. The sewage, mixed with the solution of "A B C," will flow from the top of the cylindrical tank along a channel which traverses the edge of the range of tanks. From this channel, by means of suitable outlets, the sewage thus prepared or "dosed" will be allowed to descend into each tank as may be required. Once admitted into one of these settling tanks the fluid will begin to throw down its precipitate. Each tank when full will be allowed to remain for six hours, and at the end of that time the floor of the tank will be covered with a deposit of sewage mud, while all above will be clear water. By means of pipes and valves the clear fluid will then be run off, taking its course outside along an open channel a little below the level of the tank floors. This channel is of brick, lined on the bottom with cement. It is very shallow, and has a width of four feet. It runs eastward, parallel with the river, for a distance of 400 feet, when its course is broken by half-a-dozen little falls, intended to produce cascades. Including a couple of bends, the entire course of this effluent water canal is about 470 feet. Its final destiny is to enter the Thames by an aperture in the river wall, whence it is intended to gush forth in a bright, pellucid jet, affording the strongest possible contrast to the fluid discharged from the outfall a little higher up.

At the eastern extremity of the tanks preparation is being made for the construction of filter beds, in order to afford the effluent water the highest degree of filtration. Several methods of filtration will be adopted, so as to test their relative merits, A degree of purity ample for a tidal river is expected from the operation of the large tanks alone; but further purity in different degrees will be obtained by means of the filter beds, so as to suit all requirements. A couple of fountains will also be employed, tossing their jets of clear water in the air, the water being the "effluent," and the necessary pressure being obtained by means of a small pump worked by the steam-engine, and connected with an elevated tank. The space contiguous to the Works is to be laid out with turf and shrubs, so as to present a tidy and attractive aspect. At the western end of the tanks is a neatly

designed building, within which is the Company's board-room, the laboratory, the chemical store, clerk's office, the mixing-room, and other apartments. A square tower projects in front, having a portico beneath, while the tank which is to supply the fountains occupies the upper part. The main building is simply of one storey, and is principally of wood, but has a very presentable appearance. One of the fountains is to be placed in front of it, and when all the arrangements are complete the "A B C" works will be a fair adjunct to the plateau of the Main-drainage Works. A trip to Crossness may some day become a pleasurable thing, though this would seem almost impossible. Unfortunately there are contiguous nuisances, including a manure factory of very powerful odour situated farther down the river. This establishment, though remote, is apt to make its presence disagreeably perceptible to the dwellers at Crossness when the wind happens to be in an unlucky quarter. It is one of the stipulations with regard to the "A B C" Works that they shall make no addition to the unsavoury odours which already exist. As model works they must necessarily be free from anything in the nature of a nuisance, otherwise they would not afford a satisfactory example for a country town.

Granted that the effluent water is pure, and that the Works give rise to no offensive effluvia, the final question relates to the actual utilisation of the sewage—the production of a useful and profitable manure. We have spoken of the mud deposit in the precipitating tanks. The effluent being run off to the north, the mud is afterwards drawn off by an outlet in each tank on the south. The discharge of the mud will be facilitated by men armed with brooms, sweeping the floor of the tank. The mud thus removed will enter a channel, and thence be led into a range of covered acidifying tanks, running parallel with the line of precipitating tanks. The acidifying tanks are—like the others—six in number, but of course are much smaller, as they only receive the mud. Each of the smaller tanks measures about twelve feet square by four feet deep. The mud will remain here a certain time, and, as a further settlement will take place, the supernatant water will be run off and returned to the pump sump. Sulphuric acid will then be mixed with the mud remaining in the tanks, in order to fix the ammonia. This being done, it is said that the mud never parts with its ammonia until it is absorbed by vegetation. Nevertheless, strange as it may appear, the Native Guano Company do not altogether rely on ammonia for the fertilising properties of their sewage, but believe they have an extra key wherewith to unlock the earth's treasure-house, so as to enrich the produce of the fields. The demand for their manure, and the price which farmers and gardeners pay for it, are facts which seem to indicate that this heterodox theory has some sort of foundation. The "native guano" certainly cannot be called rich in those elements which are generally supposed to constitute a valuable manure. Yet, on the other hand, it is asserted that very marked effects are produced by its use, and it finds a ready sale at £3 10s. per ton. Indeed, the demand is stated to be far in excess of the supply, and farmers who have once used it have been found eager to obtain it again.

The quantity of acid used in the acidifying tanks is not large, being one pint of acid to a ton of mud. The next step is the drying process, hitherto the great difficulty with all chemical processes. The Hastings Sewage Company, working on the "A B C" system, dry their mud on an iron floor, heated from beneath by waste steam, the mud being further acted

upon by the waste products of combustion, drawn through the chamber by a fan. The drying floor is closely roofed in, and the products of combustion, after passing over the mud, are conducted, together with the steam exhaled by the mud, into a vessel or tank, where they are made to pass through water, so as to deprive them of any noxious properties before escaping into the air. This plan, which has been ably worked out by Mr. Ovenden, the engineer to the Native Guano Company, might be adopted at Crossness. But another method is proposed, which is expected to prove more effective. The new apparatus is the subject of a patent, and is the invention of Mr. William A. Gibbs, of Gillwell Park, Essex, a gentleman already famous for his desiccating inventions with reference to agriculture. The new desiccator is already under trial at the Leamington Works. Some experiments which we witnessed a few days ago at Gillwell Park were remarkably satisfactory. A cylinder of only half the length and about one-third the diameter of the cylinders to be used at Crossness, was effectual in speedily bringing a quantity of watery mud to a state in which it would crumble in the hands. The cylinder is made to revolve slowly, while a stream of hot air from a furnace impinges radially on the interior surface of the cylinder along a narrow line parallel with its axis. The cylinder is slightly inclined, and the substance to be dried, being inserted at the upper end, travels downward with a devious motion—sometimes under the stream of hot air and sometimes away from it, until it falls out at the lower end. We saw wet oats, perfectly sodden, put in at the upper end of the cylinder, and in a very few minutes turned out at the lower end perfectly dry and sweet. As connected with this question of desiccation, we cannot forbear referring to the hay-drier, invented by Mr. Gibbs, and to the fact that by its agency it is possible to dry and stack hay in the midst of a pouring rain. The feat has been performed, and, incredible as it may appear, hay previously damaged has been restored by the process. A stack, composed partly of hay dried in the ordinary manner and hay dried by the special apparatus, shows a marked superiority in the hay which has been dried artificially, the latter having by far the most fragrant odour, and, although perfectly dry, retaining a beautiful green colour. The preference of horses and cattle for the artificially dried hay is so remarkable that no doubt can remain as to the beneficial effects of this new mode of drying. We have only to hope that Mr. Gibbs will be as successful amongst the mud at Crossness as in the pleasanter scenes of the open country.

It is computed, on the basis of certain experiments, that the 500,000 gallons of sewage to be treated daily at Crossness will result in the production of four tons of native guano. This is below the Hastings result, where 100,000 gallons of sewage produce one ton of manure. But the London water supply is large, and there is considerable percolation of subsoil water into the long lines of intercepting sewers. It will be observed that the Company at Crossness have undertaken to receive the sewage in a continuous flow, so as to represent the maximum difficulty in dealing with the sewage of a town. The Company will also take as much at night as in the day, each hour being burdened with a twenty-fourth part of the daily total. If the sewage which reaches Crossness during the night is materially weaker than that which arrives in the day, the Company are placed at a manifest disadvantage by this arrangement. As to the constitution of the manure, we may observe that at Hastings seven tons of native guano contain 3 tons 12 cwt. of "A B C," the remaining 3 tons 8 cwt. being

therefore due to the sewage. The proportions in this case, being as 72 to 68, are nearly equal. As an approximation we might assume an actual equality in regard to the London sewage. If this be so, the four tons of native guano to be produced daily at Crossness would contain two tons of sewage deposit, obtained from 2232 tons of liquid. When the Works are in operation we should expect to find the deposit somewhat heavier than this, and the yield of manure exceeding the estimated quantity of four tons per day. Our previous reckoning of seventeen grains of dry "A B C" to 10,000 grains of sewage also points to a heavier result.

The cost of the Crossness Works is estimated at £7000, and the working capital at £1000. That such an outlay should be incurred on a twelve months' experience appears remarkable. So far as the agreement is concerned, everything may have to be pulled down and removed a year hence. But the risk appears to be swallowed up in the idea of a complete practical triumph, such as shall make the "A B C" process too valuable to be discarded in a summary fashion. At the present hour the Works at Crossness are substantially complete, with the exception of the portion where the drying apparatus is to be erected, which has been delayed in order to have the full benefit of the inventive skill of Mr. Gibbs. It is expected that all will be ready by the end of October, and that the process of manure-making will then commence. Mr. William Webster is the contractor for the tanks, together with the general outside works, and Mr. Chappell for the buildings. Messrs. Appleby Brothers, of Southwark, supply the engine and the machinery. Messrs. Shelford & Robinson, of Westminster, are the engineers for the Works, associated with Mr. Ovenden, the engineer to the Native Guano Company. With regard to the cost of the Works, it is right to observe that £7000 greatly exceeds what would be necessary in order to meet the wants of a town producing 500,000 gallons of sewage per day. The Crossness Works are rendered expensive by peculiar circumstances, being intended as model works, and including many things which would be quite unnecessary in an ordinary case. It is estimated that £5000 would provide works sufficient for dealing with the sewage of a town having 20,000 inhabitants, while £1000 or £2000 more would furnish the necessary working capital. Moreover, the Crossness Works are really adapted to deal with a larger quantity of sewage than that which we have reckoned in the previous calculations. In all probability the Works are equal to the treatment of fifty per cent. more sewage than the quantity specified, making, therefore, a total of 750,000 gallons per twenty-four hours. Of course this would proportionately affect the yield or quantity of manure manufactured. Another feature in the undertaking not yet mentioned is a proposal to hire seven acres of land in the vicinity of the Works, in order to try the effect of the native guano on various kinds of crops. It is desired that this part of the operations should also be under the supervision of the Metropolitan Board, so that all the results may receive the stamp of authority and be placed beyond suspicion.

THE UTILISATION OF SEWAGE.

I.

(*From the 'Standard' of September* 30, 1871.)

A recent article in our columns gave a detailed account of the Works which are now being completed at Crossness for the purpose of experimenting with the "A B C" process on a portion of the metropolitan sewage. That this process should survive the condemnation pronounced on it by a Royal Commission, and that the shares of the Company possessing the patent should rise to a premium of 700 per cent., are matters of surprise, and even of perplexity, in many quarters. The Native Guano Company, who possess the patent, and whose shares are selling at this remarkable price, are evidently in earnest, and declare their willingness to submit their mode of treating sewage to the most rigorous test. The Works at Crossness are designed for this purpose, and it may be presumed that the Metropolitan Board of Works are somewhat favourably impressed with the "A B C" method, or they would not have troubled themselves with the surveillance of the Crossness undertaking. In the meantime the process is commanding attention abroad, and the patents which have been secured in foreign countries are made the bases of arrangements involving large sums of money. At home, such towns as Hastings, Leeds, Bolton, and Southampton are becoming identified with the "A B C" system. The manure made by this process sells at a price which is said to be highly remunerative, and upon the whole nothing could look more hopeful, were it not that eminent chemists have questioned the purifying effects of the process, and have refused to allow that the resultant manure is possessed of a value equal to the cost of production. On the question of cost, we may observe that while the "A B C" mixture remains substantially as it was before, the mechanical methods of dealing with the sewage deposit have undergone considerable change with a view to economy as well as efficiency. The cost of one of the leading ingredients of the compound, namely, sulphate of alumina, has also been very greatly reduced, by making use of clay treated with sulphuric acid as a substitute for the more expensive article. As to the actual value of the manure which is ultimately produced, adverse opinions of two sorts are expressed. It is alleged, firstly, that the so-called "native guano" possesses "a very low market value;" and, secondly, that if it is really worth anything, the circumstance is due to the 'fortifying" of the sewage with powerful chemicals. The "artificial fortification of the comparatively worthless

sewage-mud thrown down by the 'A B C' mixture" was a charge brought against the undertaking by the Rivers Pollution Commission. Inquiry into this matter, some time ago, satisfied us that any practice of this kind was extremely limited, and was never adopted with the knowledge or consent of the Board of Directors. The only incident of the kind occurred at Leamington, and has nothing whatever to do with the present position and prospects of the Native Guano Company. It would be absurd indeed to suppose that any Company seeking a commercial profit would sell a dear article under the name and at the rate of a cheap one. The good faith of the "A B C" Company is shown by the terms on which they are going to conduct the Crossness experiment; and there is every reason to believe that the Directors are honourable men, willing for their enterprise to be tested by a sound practical experiment.

Should the native guano of the "A B C" process be found to justify the expectations of the Company who possess the patent, there can be no doubt that some scientific theories of high repute will have to be reconsidered. On this very interesting part of the subject there is much to be said. But, in the first instance, we propose to make an appeal to direct facts. In order to see what is the real state of the case we have entered upon a tour of inquiry among the agriculturists who have used the native guano. At the same time we have accepted evidence as to garden produce, particularly where we can get the benefit of exact quantities. Our inquiries, which are still in process, extend through parts of Sussex, Kent, and Warwickshire. We have also made other inquiries in more distant counties, and trust that the facts thus collected will be found of service to all who are practically interested in the treatment of sewage and the cultivation of the ground. It is our own impression that a great change is impending over the practice of British agriculture, in which town-sewage will play an important part. New considerations, or, in other words, new facts, are pressing forward and cannot be disregarded, however much they may be resisted for a time. The interest excited by this question will be found to increase as the subject developes itself,—a circumstance not to be wondered at when we remember that sewage and agriculture affect both the health and the sustenance of the people.

We have intimated that facts connected with garden culture are not excluded from our inquiry. We cannot see why they should be, although the Rivers Pollution Commissioners affected to treat them with disdain. Such facts have their value, though a good deal more may be desired. If all the gardeners in England become purchasers of "native guano," that alone will establish an enormous trade. Or if any considerable proportion of the gardening class adopt this manure, the result will be by no means inconsiderable. In the meantime garden experiments help to show whether the native guano is worth anything or nothing; and we may as well say at once that, so far as our inquiries have gone at present, the testimony of horticulturists is decidedly in favour of this particular manure.

One of our earliest visits was paid to a garden belonging to a gentleman at Northiam, a few miles from Rye. The situation was on a knoll, having a light top soil of poor description, with gravel underneath, so that all the rainfall would speedily soak away. Altogether it was a very "hot" piece of ground, and as it was seldom or never supplied with water by any artificial process, it was not a very promising place wherein to seek for garden produce which should possess any degree of luxuriance. In such a

spot a dry manure could not be said to possess a good chance. Nevertheless the native guano had produced an effect. One piece of ground had been cleared of potatoes in the autumn of last year; a crop of turnips had been removed in July, and at the time of our visit, in the month of September, cabbages of various kinds were growing vigorously, though the hot sun had somewhat "scalded" them. The only manure used for these several crops was dry native guano; and until the hot sun affected them the cabbages were the finest in the neighbourhood. On an adjoining plot in the same garden the application of native guano mixed with water produced some remarkably fine vegetable marrows, altogether exceeding anything grown in the garden before. The manure was applied in the dry state to some old and seemingly worn-out strawberry plants with marked success. It was originally applied to these in patches, and the difference between the manured and unmanured portions was of a most decided character. The merit of the native guano in this case consisted in restoring the exhausted plants, so that they reassumed all the appearance of fresh ones, bearing abundance of fruit. We were also informed of a precisely similar case occurring in the neighbourhood of St. Leonards.

A singular experiment was tried in this Northiam garden, upon a strip of waste ground where nothing had been cultivated, and, consequently, no manure applied for a period of several years. This season a couple of dressings of native guano was given to this virgin soil at the rate of a ton per acre as the total of the two dressings. Forthwith everything sown upon the ground either came to perfection or made a fair approach to it. The carrots, as also the parsnips, were somewhat stunted by the hard gravel underneath; but turnips grew at such a pace that some had the honour of being exhibited at the Rye Horticultural Show. Radishes, and also mustard and cress, grew amazingly. In another spot we saw some fine black pickling cabbages. Last year the same description of cabbage was grown on the same spot under the influence of the native guano, and the crop was said to have been the finest in the neighbourhood. This year no fresh manure was employed, but the remaining virtue of last year's dressing served to produce the very satisfactory crop we beheld, and which might take rank as equal to those grown in adjacent gardens, which were, of course, duly manured each season. Another incident was in reference to some turnips. These were coming on nicely when they were assailed by the flea. To check this evil soot was applied to all except four rows, which were treated with native guano instead of soot. In the course of a week these latter had twice the growth of the turnips which had been sooted, and at the time we saw them the superiority, although lessened, was still to be observed. The fertilizing effect of the guano on scarlet runners was also evident, the bine running to twelve feet high, despite the unkindly nature of the soil.

Near at hand was a species of paddock, partly field and partly orchard, with a poor soil, something like the garden. Part of this was manured with the native guano in February last, at the rate of 6 cwt. to the acre. The first effect was a brilliant crop of buttercups. These were followed by an equally vigorous growth of sorrel. Some disappointment was naturally occasioned by these equivocal results; but a third stage speedily followed, when a luxuriant crop of grass out-topped all that had preceded it. At the time of our visit the space where the manure had been applied was characterised by a fine close undergrowth. In one place we noticed a particularly verdant kind of semi-circle, and a patch of deep green. On

inquiry, it appeared that the patch marked the spot where the truck stood which conveyed the guano to the field, and the semi-circular line was where the guano-bags, half-a-dozen in number, were finally shaken out. The appearance was much the same as if the space in question had been watered by a spring oozing out of the ground, but the growth was by no means rank.

At Guestling, itself one of the prettiest nooks in Sussex, but the scene of a fearful case of family poisoning some years ago, we met with an instance like that at Northiam, showing the effect on grass. Native guano was applied to a piece of pasture land at the rate of 3 cwt. per acre. The land was rather poor, being a hot soil of sand and gravel, and the rest of the field was manured with mould and dung. But the guano produced the finest crop. Speaking of the native guano, the party making the experiment said, "It gave a very good result, and I could see to a foot where it went." He added, "I believe it to be excellent stuff." This party had the more reason to be satisfied, seeing that he had tried the guano for his early potatoes, and found that the potatoes so reared escaped the blight, while others of the same kind, grown on the same piece, were struck with disease. The circumstance would seem to indicate that a vigorous plant, growing rapidly, is better able to resist an unwholesome influence than a plant of slower growth and lower vitality. A few days afterwards we saw some extremely handsome potatoes, grown at Walthamstow, and fertilised by the native guano. In this instance the experiment was distinctly comparative. Four rows of potatoes were dressed with two loads of stable manure, costing sixteen shillings. Four other rows, immediately adjacent on the same piece, were manured with 2 cwt. of native guano, costing eight shillings, including a shilling for carriage. The cheaper manure produced by far the best-looking potatoes, though the size was about the same. Those grown under the influence of native guano had a satin-like skin, while those grown by stable-manure had a rough, scaly appearance. The American "early rose," a new variety grown by the native guano, was a decided success.

The value of native guano as a hop manure is a subject of some importance. At Northiam we saw some results which seemed to tell decidedly in favour of the new fertiliser. A top dressing of native guano had been given to the ground last year, but with no apparent result. This year the effect was unequivocal, the rows which had received the dressing of guano being loaded with bine and hop far in excess of those which had not been so treated. It was also to be observed that these richer poles occupied the least favourable part of the garden. In this instance the manure had slumbered in the soil owing to the dry weather of last year. But we saw another case in which the manure had operated quickly. Native guano, at the rate of 8 cwt. per acre, was "shimmed in" among some Colegate hops on or about July 20. There was a little rain falling at the time, and some rain fell during the succeeding night. The testimony of the farmer with reference to these hops was, "They have improved nicely." The general effect of the native guano on the hop-plant is shown partly by a deeper shade of green in the leaves of the bine, accompanied by a more vigorous growth, naturally associated with a more abundant yield of hops. On some highly-cultivated grounds in the same district the difference produced by the native guano, "shimmed in" under similar circumstances, was less marked; but the soil had been previously so enriched with other manures that there seemed to be scarcely any margin for improvement. But here we were told,

as elsewhere, that the difference produced by the native guano consisted in the plants looking "more green" and vigorous than the rest. These hops were of the grape kind, and the ground had been a hop-garden for thirty-four years. It was in a beautiful state of cultivation, and had been known to yield a ton and a half of hops per acre. This year, despite the general badness of hops, the yield in this plantation was expected to exceed 15 cwt. per acre. It is further to be observed that on the same farm Peruvian guano was applied to some hops shortly after the application of native guano to the piece just mentioned, and no effect could be observed. At the same time, we must state that native guano had also failed in one case to produce an immediate effect. Of course so late an application, in such a season, where the cultivation was already so good, scarcely allowed of any marked result. Measured by the average result of this year's crop, all the hops on this latter farm were good, and it was scarcely possible for them to be better in such a season. In the case of a small hop-grower, whose land was of a poor description, the testimony was that the native guano proved somewhat cheaper than rape manure. That is to say, a ton of the former, costing £3 10s., appeared to correspond to half a ton of rape manure, costing from £7 10s. to £8 per ton.

In the village of Northiam an interesting experiment had been tried, of which we saw the result. A space of ground had been planted with cabbages for the feeding of cattle. One strip had been manured with stable-urine, diluted with three times its bulk of water. Another strip had been treated with Peruvian guano. A third strip had received native guano in a three-fold quantity as compared with the Peruvian; but this proportion was affected by the circumstance that the experimentalist mixed salt with the native guano to the extent of one-fourth the total bulk. It is obvious that the value of the applied manure was far greater in the case of the Peruvian than of the native guano. Looking at the entire piece of ground, we could scarcely discern any difference between the three strips, or if any difference existed it was in favour of the native guano. In all cases the growth was good, but the native material seemed to produce a somewhat finer quality of plant. Mixed with water and applied to cucumbers, the manure had produced a marked and instantaneous effect.

At Westfield, native guano, at the rate of 8 cwt. or 10 cwt. per acre on a poor soil, had been found beneficial to wheat, oats, potatoes and clover. In garden-ground, lettuce, cabbage and pease had done well. The farmer, who gave us these facts as the result of one year's experience, was satisfied that he had benefited by the manure, or, to use his own language, he had "got his penn'orth out of it." Another farmer, whose proceedings were evidently governed by caution and economy, had applied native guano to grass early in the spring, at the rate of half-a-ton per acre. The crop was a fine one, certainly better than any the land had borne for some years, but the farmer was a little undecided as to whether this extraordinary crop might not have been influenced to some extent by the manure (of another kind) remaining in the ground from the previous year. Hence he wished for another year's trial before arriving at a final decision. Should the next year's experience be such as to substantiate that of the first, it was his intention to purchase largely of the native guano, and he intimated that he and his neighbours would then be found quite ready to take all the manure that Hastings could supply.

In the parish of Icklesham we met with a large farmer, whose testimony

on the subject of our inquiry was particularly to be valued. He stated that he had a high opinion of the efficiency of native guano as a manure for clover, and also for oats. Concerning hops he would not say much at present, except that the bine was good. He began to use the manure in March. To his clover he applied rather more than 5 cwt. per acre. To oats 5 cwt., "but they wanted more." Turnips received something like a ton per acre, but the exact result was as yet uncertain, although during the first month or six weeks the turnips thus treated grew with extraordinary rapidity. It was the intention of this farmer to try the native guano on the next occasion in a somewhat different way in regard to all his crops, manuring the land with it in the autumn, and applying a second lot in the spring. Thus half a ton per acre might be used at seed-time, and a quarter of a ton in March. It was the opinion of this witness that the native guano was somewhat "hot" for some soils and "wanted water." In the garden it did well for pease, beans, lettuce, carrots and parsnips.

In the parish of Westfield we met with a remarkable instance of the rough-and-ready use of human excreta for horticultural purposes. The landlord of the "Plough" in that village takes the contents of four cesspits, and mixes the same while in a semi-fluid condition with the surface-soil of his garden, carefully covering the manure with earth, so as to prevent the escape of noxious effluvia. The cesspits contain nothing but night-soil and urine, the ordinary washings of the house going elsewhere. These four cesspits correspond to four families, comprising twenty individuals in all, the fertilized ground having a space of seventy square rods. Thus the application is at the rate of forty-five persons per acre. The plan has been carried out for rather more than three years, and the effect is seen in the extraordinary magnitude and quality of the produce. The landlord of the inn showed us the tickets which certified to his success at the recent horticultural show at Westfield, his "exhibits" having carried off four prizes of the first class, including carrots, onions, French beans and kidney-potatoes. The onions and potatoes were shown to us. The latter had a strong resemblance to those grown by native guano at Walthamstow, the skin being singularly clean and bright. The onions were splendid specimens, both in regard to size and quality. Thirty-seven bushels and a half of onions (of which these were the best) had been grown on five rods of ground. As for any nuisance which might be supposed to arise from this mode of cultivation, we were assured that there was "no smell," "not a bit," the prompt covering of the manure with earth being all that was needed. The rustic experimentalist apparently knew nothing of theoretical principles, but was content to push his way by dint of common sense and sturdy industry, animated by perfect confidence that he was on the right track. "I will grow pease," said he, "both for quality and quantity, with any man in Sussex, let him be a professional or whatever he may; and as for my French beans, they have taken four prizes in the last five weeks." It will be observed that in this case the excreta was undiluted, and could not properly be termed "sewage." It corresponded, in fact, to that which furnishes the material for Chinese fertilization, except that the Chinese are said to mix the original excreta with water, after which they pour it on the roots of the plants by means of an appliance resembling a magnified ladle. It may be doubted whether the landlord of the "Plough" at Westfield has the benefit of all the fluid belonging to the excreta, but his own opinion was that he had, and he described the manure as being in a comparatively fluid

state. The case is worth noting, and indicates how much was probably lost to British agriculture when the introduction of water-closets deprived the farmer of the fertilizing material previously gathered from the cesspools of the towns. Under the modern system the whole of this manurial matter is swept away in an artificial flood, and the ingredients have to be recovered from amidst a volume of water. The Westfield plan is simply the old farming method, and has a greater resemblance to Moule's earth-closet than to sewage irrigation, this last-named method being the consequence of superseding cesspools by water-closets, so sending all the water supply through the sewers, which likewise serve to carry off the surface-water due to the rainfall.

For the present we abstain from entering into certain considerations which the foregoing statements might be held to suggest. We rather withhold our conclusions until the facts are more fully before the reader, particularly as the more important part of our investigation remains yet to be recorded.

II.

(*From the 'Standard' of October* 7, 1871.)

From the green lanes of Sussex to the gloom of a Lancashire manufacturing town may seem a somewhat abrupt transition. But for the present it may be a useful plan to leave the agricultural part of our inquiry, and show after what manner the chemical method of the Native Guano Company is about to be applied to a great manufacturing district. The town of Bolton, which in 1801 had a population of 17,416, has now 83,000 souls within the borough, and a host of small townships gathering round it. The area of the borough is only 840 acres, or rather less than a square mile and a third. This area is covered with buildings, and future extension must lie without. The waterworks established by the corporation supply a population of 100,000, and are being enlarged so as to meet the wants of 120,000. The extension of the waterworks is urgently called for, the supply during the drought of last year having run within ten days of exhaustion—a fearful prospect for so large a population. A new reservoir of immense size is now in course of construction, costing, with other new works, not less than £250,000. The supply is given on the constant system, with an average pressure of about sixty pounds on the square inch. A rigid inspection of the house fittings is carried out for the prevention of waste, and it is said that the daily consumption is only about eighteen gallons per head; but this must be taken in connection with the other fact that there are not five hundred water-closets in the whole borough. The generality of the houses have cesspits, which drain from beneath into the sewers. These cesspits receive the ashes of the household, and the solid matter is removed at intervals by the corporation, who transfer it to their depôt, where it is dressed over, and finally sold to the farmers at about a shilling a ton. Thus the sewers receive the liquids from the cesspits, together with whatever goes down the sinks of the houses, as also the surface water due to the rainfall and the liquid refuse from the factories. The total sewage of Bolton

is stated to be 1,750,000 gallons per day. Some of it is carried off by a stream called the Nile, which is now completely enclosed, and takes the form of a sewer. A great portion of it goes into the Croal, a shallow stream which flows through the town, and which emerges from the precincts of the borough in a state of utter blackness, corresponding to the imprisoned waters of the Nile. Under an order from the Home Secretary the corporation have proceeded to intercept the sewage from entering the Croal within the boundaries of the borough, and the works for this purpose will be completed by the close of the present year. Of course to exclude the sewage from the river at one spot, and to cast it in at another, is not an effective mode of dispolluting the stream. The plans of the corporation, however, do not end here. They have in prospect the treatment of the sewage after a fashion which shall leave nothing but clear water to go into the stream. In other words, they are giving a trial to the "A B C" system of the Native Guano Company, in the hope that it will extricate them from their difficulties in regard to the final discharge of the sewage. The treatment of the sewage by irrigation was at one time proposed; but the obstacles were many. It would be necessary to pump the sewage to a height of 250 feet, and the entire expense of an irrigation scheme could not have been less than £150,000. Whatever scheme may be adopted, the mill-owners are especially anxious that not a particle of water-power shall be lost. Every pint of water is jealously looked after, whether it happens to be clean or dirty. The mill-owners cannot establish a claim to the sewage, but they say that if the sewage is kept out of the river a certain quantity of surface-water will also be diverted from the stream, and will be lost to them as an agent for turning their wheels and working their machinery. Thus the corporation seem to be fixed between the horns of a dilemma. If they intercept the sewage they are accused of robbing the stream, while if they feed the stream they are liable to pains and penalties for polluting it. Such are some of the special difficulties of a manufacturing town. The enormous and rapid growth of towns devoted to manufactures is fraught with sanitary complications. The most lovely valleys, flanked by magnificent hills and watered with winding streams originally of pellucid clearness, have all their beauties sullied by the erection of factories, chemical works, and other industrial establishments, the liquid refuse spoiling the stream, while the dense smoke from the chimneys darkens the blue sky and blurs the loveliness of the otherwise charming landscape. Ugliness is fast blotting out beauty, while men multiply, and towns are added to towns. In the neighbourhood of Bolton and Manchester the district is so fully inhabited that in one direction there is a continuous line of gas-lights for twenty-five miles. The necessity of providing carefully for the water-supply and drainage of these aggregated populations is obvious, and the drought of last year has very properly been taken as a warning on the first of these two points.

On the occasion of our visit to the experimental sewage works at Bolton we were very courteously met on the spot by the mayor of the borough, Mr. Thomas Walmsley, accompanied by the town clerk, Mr. R. G. Hinnell, and the borough engineer, Mr. Henry Baylis. These gentlemen, together with Mr. Robert G. Sillar, one of the directors of the Native Guano Company, and who acts as manager and chemical superintendent at Bolton for a time on behalf of the corporation, afforded us all the information that could be desired. The works constructed for the trial of the "A B C" system are not yet in actual operation, but have evidently been prepared in

the expectation that the experiment will prove successful, and the entire construction appears to be of a very careful and perfect character. The whole cost of the Works is borne by the corporation, who will also conduct the manufacture, bearing the entire expense, and giving the Native Guano Company a royalty to the extent of 25 per cent. of the manure made. The Works, as at present constructed, are intended to deal with only about one-third of the sewage, and have cost the borough £7000. But they have been laid out with a view to extension, and it is thought that £15,000 would suffice for the treatment of the whole of the sewage, though we should apprehend that this would scarcely be a sufficient sum in the event of water-closets becoming general in Bolton. One indication of the contemplated enlargement is afforded by the chimney of the Works, a well-built and shapely shaft, 150 feet high, considerably exceeding the present boiler power. The main building, a substantial structure of brick, measures 96 feet in length by 60 feet in breadth, the interior walls being 17 feet high. There is also a basement of 8 feet pitch. The situation of the Works is immediately below the point where the new outfall will have its discharge. The ground is close to the river, on the floor of the valley, and is much lower than the general level of Bolton. It borders on the township of Haulgh, just above the spot where the Lancashire and Yorkshire Railway crosses the valley and the stream. The sewage to be dealt with for the present is that which comes down through the Nile culvert, having its rise in the Bolton Moor district. This amounts to 500,000 gallons per day, the same amount, therefore, as that which will be dealt with at Crossness, near the southern outfall of the metropolitan sewage. The trial may extend over a year, or a decision—more especially if favourable—may be arrived at much sooner. The advantages for the manufacture of the manure are very considerable here. A hillside of clay has been purchased close to the Works, and is in the course of being dug out. A manufactory of sulphuric acid is hard by. Coal is forthcoming at 5s. 6d. per ton. There are as many as eighteen varieties of clay in the neighbourhood, all good for the purposes of the "A B C" mixture. These are circumstances which all aid the undertaking, and will naturally facilitate its success. On the other hand, the determination of the mill-owners to have the full benefit of the water power necessitates the pumping of the effluent water up to a certain level, and although the height is not great, being only a few feet, the consequent employment of steam power is a source of expense.

According to the arrangements now just about to be carried out, the sewage—as brought down by the Nile—will enter the main building on the western side, and pass through a well or pit, into which a solution of the "A B C" mixture will be continually flowing. From thence the sewage, thus "dosed," will flow out of the building on the northern side into one or the other of two systems of tanks. These tanks, which are fully exposed to the air, are of brickwork, with copings of millstone grit a foot thick. Their average depth is six feet, and their area (including some smaller ones, available for experimental purposes) 1600 square yards. Three tanks, with an aggregate capacity of more than 140,000 gallons, constitute each set. It will take from six to seven hours to fill one of these sets. Precipitation will be going on to some extent while the tanks are filling; but the process will be more rapid subsequently. The two systems of tanks alternate with each other, the sewage flowing into one set while the other is being rested and emptied. As the process of

precipitation goes on the upper part of the fluid will become clear. A falling penstock, working upon a cogged-quadrant of cast-iron, provides for running off the water from the upper part of the fluid, the penstock descending to any level short of a few inches from the floor. The water thus run off goes into a square well-hole, where a centrifugal pump, by Messrs, J. and H. Gywnne, capable of lifting 3000 gallons per minute, and worked by a twelve-horse portable engine, raises the effluent water to the level which discharges into the goit. But for the demands of the mill-owners the water might be discharged at once into the bed of the river, which is at least twelve feet lower than the goit, there being a fall in the river to that extent just here. At the time of our visit the goit was taking the whole volume of the Croal, not a gallon of water per minute going over the sluice. When the tank has been discharged nearly down to the level of the deposited mud, the remaining water begins to be somewhat dirty. This dirty water is run off into a well-hole provided for it, whence it is raised by a three-throw pump and returned to the sewage-well, where it mingles with the sewage which enters from the Nile, and is again subject to the dosing with the "A B C" solution. Of this dirty water, requiring a second treatment, there will be but a small quantity. With this slight exception, the sewage will be separated into two parts—the mud which lies at the bottom, and the effluent water which flows off to the well, whence it is pumped into the mill goit. This effluent water is to be clear and inodorous, and such as would inflict no sort of pollution on a pure and wholesome river. Until all the sewage of Bolton is thus treated the operation now described will be somewhat ludicrous, seeing that the effluent water, after all its careful purification, will be discharged into a river which will be utterly black with impurity. Half a million gallons of sewage will be purified, and 1,250,000 gallons will remain as before. This state of things, however, will not long continue. As soon as the lesser operation is found to be successful the larger one will be undertaken, and the whole sewage of Bolton will be dealt with on the "A B C" system.

Having followed the course of the liquid which flows from the precipitating tanks, we have now to consider the fate of the mud. Within the main building is a high-pressure stationary engine, of eighteen-horse power, by Messrs. Fawcett and Shackleton, of Leeds. This engine performs a variety of operations, including the process of sucking the mud from the tanks through a pipe, into a well within the building. To facilitate this withdrawal of the mud the floors of the tanks have a fall towards one spot, where the mud-pipe enters. The mud having been drawn away into the well just mentioned, is pumped up into an iron tank, having three compartments. Here the mud undergoes a further settlement, and the top water is run off into the sewer, after which the mud flows down a pipe into what is termed the acidifying tank. On its way it becomes mixed with sulphuric acid, which enters the pipe through a funnel having a syphon bend so as to prevent the escape of any noxious gas. The sulphuretted hydrogen is neutralised by burning sulphur in the acidifying tank. From this tank the mud is run off to the drying floors. These are of sheet iron, under which steam is passed, the latter being enclosed by sides and a bottom of lead, the space intervening between the iron and the lead being only a few inches in depth. Over the floor is a low roof of wood and felt, like a small garret or loft, the roof coming down to the floor and forming a

triangular section. This is made as tight as can well be managed, so that a flue entering into the adjacent chimney may bring the heated air and smoke from the boiler fires over the surface of the mud. Hot air, smoke, and moisture from the mud, will thus be accumulated at this spot; and should any offensive smell yet remain, it is proposed to pass the gases and vapours through water, so as to remove all possible source of annoyance before discharging them into the chimney. An odour of butyric acid is thought to be all that can arise here, and this could be at once destroyed by passing it through water. If needful the passage of the air and vapours over the drying floors will be facilitated by the use of a fan to draw the air, not forcing or blowing it. There are four roofs over the drying floor, which is thereby divided into four parallel sections. Preparations have been made for another floor, to occupy a position above the present one. The remainder of the Works we need not refer to at any length, as they chiefly consist of appliances for making the "A B C" mixture.

We may observe that the situation of the Works is so low that the water supplied by the corporation through their pipes has a pressure of 120 lbs. to the square inch. Under such a pressure a short tube of India-rubber or gutta-percha swells out like a bladder, and will speedily burst unless the water is either turned off at one end or allowed to escape at the other. Most of the organs in the churches and chapels of Bolton have their bellows worked by the pressure of the water supplied from the mains, the price charged being about fifty shillings a year. In other cases, where the power is used in manufactories, a charge is made at the rate of sixpence per 1000 gallons. We have already remarked that the average pressure is about 60 lbs. per square inch. The accounts of the past year show a balance in favour of the corporation on the waterworks account to the extent of more than £7000. The public affairs of Bolton appear to be administered with a good deal of spirit. The market is a spacious and admirably arranged structure, lofty and well lit. It is the property of the corporation, who are also building a new Town Hall on an imposing scale, in the classic style. The munificence of a private individual has furnished the inhabitants with a new parish church, opened about two months ago, and costing, it is said, about £50,000.

We have already intimated that the "A B C" process is not yet in actual operation at Bolton, the Works not being fully complete. But a few weeks will probably see them finished, and as the whole affair will be carried on by the corporation of the borough the results may be relied upon as thoroughly independent and unbiassed. The confidence of the Native Guano Company is shown by their agreeing to take their remuneration in the shape of the manufactured manure, which will simply be drawing a blank if "Native Guano" is no better than some chemists assert. On this question of value we are still collecting evidence.

In contrast with the borough of Bolton we may refer to the town of Tunbridge Wells, on the confines of Kent and Sussex, a place with a moderate population, and free from the nuisances often associated with great manufacturing processes. Despite its advantages Tunbridge Wells became subject to Chancery proceedings in respect of its sewage. First, there was an injunction, and afterwards a writ of sequestration. The local authorities thereupon adopted measures for applying their sewage to agricultural purposes. Tunbridge Wells is a water-closeted town, with a population of 19,400, and a water supply which is said to range between

20 and 25 gallons per day per head. At a cost of £90,000, the local Board of Health have succeeded in establishing a couple of "sewage farms," one to the north of the town, and the other to the south. This expenditure includes the fee simple of the land, together with the cost of carrying the sewage to the respective sites, and all the necessary expenditure connected with the undertaking, not omitting the compensation claimed by parties whose lands were intersected by the outfall sewers—an item which proved rather burdensome. The north farm consists of 120 acres, and the south 170. This for a population of 19,400 allows about 67 persons per acre. The north farm has been in operation about two years. The south farm is only just getting into working order. In the former instance, land which would scarcely let for 15s. an acre, and which certainly would not command more than £1, has undergone such improvement than in its present state it is reckoned as worth from £5 to £7 a year. Of course we must take this rental as including the sewage. Six crops of Italian rye-grass have been gathered in the year, reaching an aggregate of £48. Wheat, oats, barley, mangold, sugar-beet, swedes, cabbages and French beans have all done well. Ordinary grass has yielded a very heavy crop of hay of excellent quality. The soil is sandy, and the sewage is applied by means of open carriers. The effluent water is said to be very pure, and samples shown to us by the town clerk, Mr. Lewis, appeared to bear out that statement, so far as colour and smell were concerned. We were further assured that there were no complaints of offensive smells as arising from the application of the sewage to the land. In a sanitary and agricultural point of view all was satisfactory. But the land was too dear for agricultural purposes, its real position in the market being that of building ground. Hence £20,000 was paid for 120 acres, which as farming land would scarcely have been worth £5000. This is one of the difficulties of irrigation. To get cheap land it will sometimes be needful to carry the sewage to a great distance, thereby entailing expense for the construction of the necessary works, with, perhaps, the addition of a permanent charge for pumping. If the sewage is discharged at a moderate distance there is the likelihood of having to buy building land for the purposes of the farm. In such instances, a good chemical process would be a great boon. If the "A B C" proves successful, an immense amount of trouble and expense will be saved to many towns. Thus we see in the case of Bolton that the Native Guano Works are expected to cost only about £15,000 for a population of more than 80,000. Tunbridge Wells, with less than 20,000 inhabitants, spends £20,000 for the purchase of one of its farms. Of course the farm yields a return; but it seems too much to expect that a commercial profit will accrue. The Native Guano Works will also yield a return, and, if present expectations are realised, the profit will be very large. Certain other aspects of this question will be discussed in a subsequent article.

III.

(*From the 'Standard' of October* 12, 1871,)

Having described the position and prospects of the "A B C" Works at Bolton, we now proceed to do the same in the case of Leeds. The Sewage Works on the "A B C" system at Leeds, like those at Bolton, will be commenced on an experimental basis. The quantity of sewage to be experimented upon at Leeds is larger than at Bolton, being a million gallons per day instead of half a million. But relatively to the entire mass of the sewage the quantity is smaller, being only a thirteenth of the whole; whereas at Bolton the proportion is more than a fourth, being 500,000 gallons out of 1,750,000 per day. The population of the municipal borough of Leeds at the taking of the recent census was 259,201, so that the sewage has the high ratio of fifty gallons per head daily, or rather more than eighty tons per annum. At Bolton the daily proportion is twenty-one gallons per head, or thirty-four tons per annum. As mentioned in a former article, Bolton has not 500 water-closets in the whole borough. Leeds is also deficient in this respect, but in a much less degree than Bolton.

The corporation of Leeds have expended £10,000 on the "A B C" Works in their present form, and it is estimated that to extend the Works so as to include the whole of the sewage would require a total outlay of £30,000, or perhaps rather more. Proportionately this is a lower rate of expenditure than the outlay at Bolton. But the Leeds Works, excepting one great tank, have a less substantial and finished appearance than those at Bolton. A good deal of expense has been incurred in the construction of the heavier portion of the Works, owing to the swampy nature of the ground. The plan of the Works is also somewhat defective, a result which may be attributed to want of experience at the outset. If the Works are extended, it will probably be found worth while to alter some of the levels. The spot itself is unpleasant enough and awkward to get at. As sewage works are seldom visited except from utilitarian motives, the attractiveness of the site is of little consequence. If the sewage works are able to conquer the nuisances, and so render the locality agreeable, so much the better, and the transformation will afford a proof that the system pursued is so far a good one. At present the Leeds establishment is approached by first of all crossing the river Aire in a boat, and then picking one's way across the lock-gates of the adjacent canal. If the river and the canal were in a state of purity the expedition might be pleasant enough. But the condition of the river is abominable; and as for the canal, all manner of filth, including the putrefying carcases of defunct dogs and cats, accumulates against the gates. The river is a sewer, of pitchy blackness; while in regard to the canal, we can readily believe that the stench at the lock-gates is in summer time often frightful. The Rivers Pollution Commissioners have given a graphic description of the sanitary state of Leeds, with its river and "becks." They described the borough (in 1866) as consisting of about 45,000 houses, having 12,000 privies and cesspits, besides water-closets, of which they reckoned there might be four or five thousand. The removal of the contents of the privies and ashpits took place during the night, at which time the stench was "fearful." About 55,000 tons of the refuse were removed every year, at a gross cost of £7000, and an actual loss of about £4000.

The Commissioners refer to the foul state of the becks and the river, saying the state of the water may be inferred from the fact that as many as fifty carcases of pigs, dogs, cats, &c., have been removed in the course of a day, adding, "but it must not be inferred that these carcases are removed with any degree of regularity." Dye works, tanneries, and various other manufactures, continually pollute the river with their foul refuse. An attempt was made to irrigate grass land with the fluid refuse from some of the tan-pits; but the effect was to injure the grass, a result which the Royal Commissioners explain by saying that the manure was "too strong."

There was a time, within the memory of man, when the water of the Aire was used for domestic purposes. But the subsequent pollution of the stream rendered the continuance of this arrangement impossible, and other sources had to be sought out. The present supply is constant, and belongs to the corporation. It averages about thirty gallons per head. The drainage of the town is collected by a main sewer, nearly eight feet high and about five feet wide, which flows down to Knostrop, where it becomes an open canal, which runs its course for three or four hundred yards and then discharges into the much-abused Aire. The corporation are under an injunction to abstain from polluting the river, and the order would have been enforced against them were it not that they undertook to make a trial in good earnest of the "A B C" process. In the meantime the injunction is held over. Irrigation would have been a very difficult remedy in the case of Leeds, the only suitable land being six or seven miles distant, and the intervening country very hilly. The arrangement with the Native Guano Company is that the corporation shall erect the Works and find the machinery and appliances, but the Company will carry on the process of manufacture, paying the corporation 5 per cent. on the original outlay, out of profits, and 15 per cent. of the net profits. The experimental stage will last for twelve months if found needful, or will merge in a complete enterprise at an earlier date should success be more speedily demonstrated. The chemical superintendent of the Works is Mr. James Wylde, and the treatment of the sewage is just now commencing.

Standing by the mouth of the main sewer, just where it changes itself into a canal, we saw the foul liquid tumbling out in a state of blackness and froth, while something rather worse than an ordinary sewage odour affected our sense of smell. Manufacturing processes evidently had something to do with the detestable effluvia which assailed us, and we were informed that this was indicated by the varying quantity and quality of the sewage in the various parts of the day, the difference often being great and sudden, particularly in regard to quantity. But the sewage is said to be easy of treatment. It is very dense, and has a large deposit, which we may presume will render it more profitable to the Company. A pipe leading underground from the mouth of the outfall sewer conveys the sewage to the Works, which are close at hand. Here the sewage enters a well or pit, properly constructed, where it is mixed with the "A B C" solution, and whence it flows into an open tank having a capacity of 250,000 gallons Four charges in the twenty-four hours would thus correspond to a million gallons. The tank has a total length of 175 feet, with a breadth of 25, and a depth of 12 feet. It is sunk in the ground, and the masonry and brickwork are very substantial. The sewage enters at the end where the mixing-pit is situated, and after traversing the whole length of the tank flows over into a division at the other end, the overflow being regulated by a barrier, which

can be made to rise and fall vertically in grooves, the contrivance being sufficiently water-tight to prevent any undue escape of the fluid. The movement is effected by a rack and pinion arrangement, assisted by counter-weights. The sewage in the tank having been previously mixed with the "A B C" solution, undergoes a rapid precipitation, and as this takes place the clear top water is run off over the barrier, which is lowered as the precipitation of the sewage goes on. The clear water, or "effluent," thus drawn off, is conveyed away by a large pipe, leading into the sewage canal, which it enters at a point about a hundred yards below the mouth of the main sewer. When the water in the tank has sunk too low to flow any further in this direction, a centrifugal pump, made by Messrs. Gwynne and Co., of London, and capable of throwing more than 3000 gallons per minute, begins to operate. This pump, in common with other parts of the machinery, is worked by an excellent 16-horse high-pressure engine, made by Messrs. Fawcett and Shackleton, of Leeds, by whom the machinery employed in the Works has also been manufactured. This centrifugal pump lifts the remaining water up to a higher level, so that the fluid may be able to fall into the sewage canal.

The effluent water being thus disposed of, the mud is pumped from the floor of the great settling tank into the acidifying tanks within the principal building. In these tanks the mud undergoes a further settlement, and the supernatant water is syphoned off, returning to mingle with the sewage which flows into the mixing pit. The remaining mud in the acidifying tanks is then mixed with sulphuric acid and run off to the drying floors, taking its course through a pipe and along a trough. The drying floors are of sheet-iron, heated by steam beneath and hot air above, the hot air being obtained from the boiler fires and passing by a flue into the chimney. The mud when thoroughly dried becomes the "Native Guano," the virtue of which is being tested in various forms of cultivation both at home and abroad. At these works it is not demanded at present that the sewage shall be dealt with continuously. Otherwise it is scarcely conceivable that one tank would be sufficient. But if the experiment should prove successful in its present form, the Works will be enlarged, so that the whole of the sewage may be treated without interruption, the sewage canal being thus converted into a conduit of clean water.

The economy of sewage is a question worth considering. At the Hastings Sewage Works the "A B C" process is producing native guano at the rate of 2000 tons per annum from a population of 25,000. The manufacture has not yet been developed to that extent; but such appears to be the ratio. At Northiam a strip of barren ground, unmanured and uncultivated for years, was fertilised by the application of guano at the rate of a ton per acre. Supposing this quantity (itself a large one) to be generally applied by farmers, the produce of the Hastings Works would then suffice for 2000 acres. We might easily reckon on its doing more. On the other hand, suppose we take the figures afforded by the use of sewage at Westfield. Here the contents of the cesspits were applied to the land at the rate of forty-five persons per acre. Used in this proportion, the sewage of the 25,000 at Hastings would only suffice for 555 acres, or little more than a fourth of the space which would be treated by the native guano. At the Lodge Farm, Barking, according to the statement of Mr. Henry S. Morgan, sewage has been applied this year at the average rate of 3800 tons per acre. If we take the London sewage at fifty gallons per head per day, or about

eighty tons per annum, these 3800 tons will correspond to about forty-seven individuals of the population, which is very nearly the same as the quantity we have mentioned as producing such remarkable results at Westfield. At Tunbridge Wells we found the proportion to be about sixty-seven persons per acre. Mr. W. Hope, whose treatment of the Romford sewage at Breton's Farm is the finest specimen of sewage irrigation to be found anywhere, uses 3600 tons per acre as a maximum. It would appear from Dr. Corfield's *Digest*, that Mr. Hope generally reckons on using the sewage of from thirty-five to forty persons per acre, supposing the dilution to be at the rate of twenty-five to thirty gallons of water per head of the population daily. The quantity thus distributed would range from 1400 to 2000 tons per acre per annum. In his recent report on the Birmingham sewage, Mr. Hope appears to speak of thirty-five persons per acre as a maximum number. At this rate the Hastings sewage would fertilize 714 acres, as against the 2000 or more of the Native Guano Company, whose proportion comes down to a maximum of twelve and a half persons per acre.

On this subject, the Rev. H. Moule has recently presented some extraordinary calculations.* This gentleman proposes to employ the earth closet system in the production of a dry manure, and believes that by such means it would be "perfectly feasible to manufacture a manure equal in power to guano." This manure, he states, if sold at £3 per ton, would realise a profit equal to £1 per head of the population; but he believes that the manure would sell for as much as £5 per ton. Mr. Moule thus speaks of his plan:—"I now proceed to assert the applicability of the dry earth system to the removal and disposal of sink-water and other kitchen refuse, together with bed-room slops, as being so complete that such removal and disposal shall be not only safe and free from all nuisance, but so profitable when mixed with the used earth and with other refuse, such as bones, soot, &c., that it shall yield a manure the minimum value of which may safely be estimated at £1 per head per annum on the whole population of a given town." He says that this statement "requires not the support of chemical analysis, for the fact is unquestionable that under this new process all the ammonia, the nitrogen, the phosphates, the sulphates, the carbon, the salts, and, yet more, the silica contained in the entire refuse of a given town may be concentrated in earth, the weight of which shall not exceed, and may be much less than that of 1000 tons per 1000 people." It will be observed that the "A B C" plan produces manure (at Hastings) at the rate of 2000 tons per annum for a population of 25,000, the manure selling at £3 10s. per ton. Mr. Moule goes on to explain that by reducing the quantity of earth per 1000 people to 500 tons per annum, the value of such a manure would be, at least, £5 per ton. The sum of £500 is expected to cover the working expenses for a population of 1000. Selling the 500 tons at £3, the return would be £1,500, leaving a profit of £1000, or £1 per head. Selling at £5 per ton, the profit would be £2 per head. Such figures go immensely beyond the expectations of the Native Guano Company, who, nevertheless, are thought by many to be extremely extravagant in their notions. But Mr. Moule touches on a valuable principle when he says, "Mr. Bailey Denton has recommended the people of Hitchin to apply the sewage of their town of 7000 inhabitants to 60 acres of land. Saved by the process of which I have spoken, that manure is sufficient for 7000

* *Vide* 'The Times,' October 3, 1871.

acres, or at the lowest estimate sufficient for 3500 acres." By the plan of the Native Guano Company the sewage of 7000 persons would fertilise from 560 to 1120 acres, according as the native guano was applied at the rate of a ton or half a ton per acre. Mr. Henry Morgan would apply this sewage to 150 acres.

In quoting the calculations of the Rev. H. Moule, we must say they appear to be far ahead of probability. The principle involved is worth looking at, and that is all we can allow. The "A B C" plan seems really to produce the concentrated manure which Mr. Moule talks about, although the figures are much less imposing, and at the same time are much less alarming, although admitting the use of water-closets. If Mr. Moule is right in theory, the Native Guano Company may be found correct in practice. Mr. Moule would absorb the excreta in dry earth, whereas the "A B C" operators would precipitate the manurial elements of the sewage and form the deposit into a dry compound, the effluent water running off in a clear state from the precipitating tank. Chemical, agricultural, and commercial questions are involved in the process, and there is considerable comfort in the thought that the controversy now raging must soon be settled by an appeal to facts. Some important results are already ascertainable, and to these we shall speedily refer.

IV.

(*From the 'Standard' of October* 16, 1871.)

It is commonly alleged that the "A B C" method of treating sewage has been abandoned at Leamington, and the plan of irrigation adopted as offering the only practicable resource. Viewed without explanation, there are certain facts which would seem to warrant this conclusion. But the fuller history of the sewage question at Leamington shows that the "A B C" system did not fail there in the manner which some have supposed, although the process was subject to peculiar local disadvantages. So far is Leamington from proving the hopelessness of the "A B C" method, that we have found in that locality—especially on the surrounding farms—some of the strongest evidence in favour of the undertaking. Commencing with a period about four years ago, we find the leading inhabitants of Leamington greatly dissatisfied with the manner in which their local affairs were conducted, particularly in reference to the sewage. A memorial, very extensively and influentially signed, was presented to five selected individuals, urging them to allow themselves to be put in nomination as members of the local Board of Health. These five gentlemen consented, and were duly elected, one of their number, Mr. S. U. Jones, being subsequently appointed chairman of the Board. Leamington, like some other towns, suffered from legal proceedings on account of the nuisance occasioned by its sewage mingling with the adjacent waters. A Chancery injunction was followed by a writ of sequestration, and with all this cost and annoyance was associated the risk that Leamington would lose its character as a watering-place, and

thereby experience a decline in its prosperity. A town so largely dependent on the favour of the upper classes could not possibly endure this prospect, and the fact that the name of Dr. Jephson appeared on the memorial or address previously mentioned was quite sufficient to show to all who were acquainted with the locality that the state of affairs was serious. It is generally allowed that to Dr. Jephson is Leamington indebted for many of its greatest improvements, a circumstance indicated by the fact that the splendid subscription gardens in the centre of the town have been named after this gentleman. We may observe, in passing, that the Jephson gardens and those of the adjacent pump-room help to render Leamington one of the finest specimens of the *rus in urbe*, and the general management of the town is such as to reflect the highest credit on the local authorities.

Of course it was not to be tolerated that all these excellences should be neutralised by pouring into the Leam a mass of putrescible matter, fouling the otherwise beautiful river, and giving the town a bad name. Imbued with fresh blood, the local Board of Health proceeded to consider what was really the best course to be adopted. The chairman, Mr. S. U. Jones, visited Leicester, and saw the results of certain experiments made with the "A B C" process. Mr. Jones was so impressed with what he saw as to feel satisfied that the system was likely to be of service. Samples of the effluent water were brought to Leamington, and after a certain amount of investigation, accompanied by negociations with the patentees of the "A B C" process (the Native Guano Company not being then formed), it was resolved that the patentees should have the use of the Sewage Works at Leamington for the purpose of making a decisive experiment. A provisional agreement was entered into between the local Board and the "A B C" patentees that the latter should deal with the raw sewage, while the Board should take charge of the effluent water. At this stage of the affair, a deputation from the local Board waited on the Earl of Warwick, asking his lordship to enter into an arrangement whereby 100 or 120 acres of his estate would be made available for the reception of the effluent water just referred to. His lordship received the deputation in a very kindly spirit, and entertained the proposal. As between the local authorities and the "A B C" patentees, it was agreed that while the latter had the free use of the premises and plant of the local Board, the Board should have half the net profit arising out of the manufacture and sale of the manure. The bargain was thought to be a promising one for the town. But the Earl of Warwick ultimately thought that the "A B C" process was a little too good, and would take so much of the fertilising matter out of the sewage as to render the effluent water of little service to the land. His lordship consequently came to the conclusion that he would not assent to the proposal of the Board, and intimated that he would neither let nor sell the local authorities any land for the reception of the effluent water. But the earl opened another way out of the difficulty by offering to take the raw sewage and deal with it himself. His lordship being topographically master of the situation, the local Board had no resource but to comply. At that time the Board had not sufficient confidence to decide on sending the effluent water direct

into the stream. Their previous failure with the lime process may have somewhat shaken their nerves. Their anxiety to get rid of the sewage in the most ready and assured manner induced them to close with Lord Warwick's proposal, and accordingly the contemplated agreement with the "A B C" patentees was given up, in order to carry out the plan favoured by the noble earl. But as it was necessary that the sewage should be dealt with in some way during the interval in which the irrigation works were being prepared, the Board entered into an arrangement with the Native Guano Company (just then formed), whereby the latter undertook, in March, 1869, to apply their "A B C" process to the sewage of Leamington, pending the execution of the works required for laying the sewage on Lord Warwick's farm. Thus, so far as the Company were concerned, the agreement was from the first of a purely temporary character.

The Rivers Pollution Commissioners paid their first visit to the Leamington Sewage Works in December, 1869, some months, therefore, after the final agreement between Lord Warwick and the Leamington Board. Consequently, the unfavourable report which the Commissioners made concerning the "A B C" process had no effect in causing the local Board to adopt the irrigation plan. That the report of the Royal Commissioners was decidedly unfavourable is a fact sufficiently well known, and for a time it exercised a very depressing effect on the prospects of the Company. But the process continued in operation at Leamington, and not without a considerable degree of success. The purity of the effluent water has varied, a circumstance apparently arising from an inequality of treatment. At times it has not been so clear as could be wished, while at other times it has been altogether clear and free from smell. The Native Guano Company assert that the Leamington Works, being originally established for the treatment of sewage by the lime process, were not capable of being properly adapted to the "A B C" system, and that they have all along worked at Leamington under great disadvantages. On the occasion of the visit we recently paid to the spot, we found the place in a sort of transition state, the irrigation scheme being just about to come into operation, while the "A B C" process was still being applied. The state of affairs was such that we could not reasonably look for any very successful results; nevertheless the water then flowing into the Leam from the Sewage Works was simply a little turbid, and differed altogether from the appearance which sewage itself would present. Neither were the Works particularly offensive, although some drying experiments were then going forward in the open air. We should say that any ordinary gas works would have been quite as disagreeable to a sensitive nose as the "A B C" establishment at Leamington, and of the two we should expect to find the gas works rather the worst. Complaints have been made of these Works, but although we paid them more than one visit we encountered no offensive effluvia, except in some of the more confined parts of the premises. How it may be at other times we cannot say, but such was our experience, although about the same time somebody lodged a complaint, in consequence of which the manager of the Works was requested to make no more drying experiments after a certain hour in

the morning. On this point we may say, that while standing close to the experimental drying machine, and at the mouth, where all the vapours escaped, we experienced nothing in the nature of a bad smell, although we were conscious of a hot, damp blast, such as would cover a mirror with steam in a moment. It is also to be observed that notwithstanding this complaint the authorities asked the Company to prolong their stay and to treat the sewage for a further period until the Irrigation Works were quite ready.

That it is practicable by means of the "A B C" process to precipitate town sewage so as to produce a clear effluent water seems undeniable. In fact, this result might be obtained by more than one method. The difficulty always consists in dealing with the matters in solution. The Native Guano Company claim that by the "A B C" process they separate the sewage into two parts, one being a deposit which on being dried becomes a valuable manure, while the other portion consists of a fluid fit to run into any stream which is not used for drinking purposes. By passing the effluent water through a filter, or by discharging it on to land, a still higher degree of purity may be obtained. The amount of land required for this purpose is estimated as very much less than that which is necessary for the utilisation of raw sewage, the area required for the effluent water being only about one-sixth of that which would be necessary for sewage. Another point consists in the value of the deposit. Not only must the sewage be purified, but if the undertaking is to be commercially successful the materials of the sewage must be thrown down in such a state as to be suitable for the use of the farmer. The lime process will clarify sewage in a high degree, but the deposit is almost valueless. The "A B C" deposit consists of a sewage precipitate mixed with the products of the chemical solution, the latter comprising a crude sulphate of alumina (manufactured in the manner we have already described), together with animal charcoal, a minute portion of blood, and a certain quantity of clay. The next step in the operation is that which relates to the drying of the deposit. Great ingenuity has been exercised in accomplishing this final stage, it being necessary to avoid creating a nuisance, while at the same time doing the work economically, and in such a way as not to deteriorate the value of the manure. The point on which information seems most to be required is that which relates to the manurial product. The Royal Commissioners have boldly said:—"The manure obtained by this process has a very low market value, and cannot repay the cost of manufacture." According to the prevalent method of estimating the value of a manure, using the customary chemical analysis, the Commissioners are probably right. But there are reasons for disputing the grounds on which that estimate is based. These reasons are partly scientific and partly practical, and as facts are better than abstract arguments we proceed to give the public the benefit of such practical results as we have been able to meet with.

As the centre of a rich and important agricultural district, Leamington is well situated for the sale of a cheap and efficient manure. When the "A B C" process began to excite attention in the town, the subject naturally arrested the notice of those parties who

sold artificial and other manures to the neighbouring farmers. One of the firms thus interested proceeded to pay special attention to the subject, and a series of experiments were set on foot by Mr. Creswel, of the firm of Jacks and Caswell, a gentleman who subsequently gave evidence before the Parliamentary Committees to whom certain sewage bills were referred. Mr. Caswell obtained a bag of the first lot of "native guano" manufactured at Leamington. His primary effort was to discover whether the material possessed any fertilising properties at all. On this point he was soon satisfied, particularly in the case of plants belonging to the Brassica tribe. The commercial value was the next question, and in proceeding with this part of the inquiry Mr. Caswell found he obtained better results by digging the manure into the ground than by merely applying it as a top-dressing. A strip of garden ground about an acre in extent was divided lengthwise down the middle, one half receiving eight tons of stable manure, while the other moiety had half a ton of the native guano. The stable manure, including carriage, would be worth £3, while the guano would cost only £1 15s. Various crops were then sown or planted in parallel order across the strip, so that each bed was half in stable manure and half in native guano. As the crops came on, those parts which were in the guano were always a little in advance of the other. This was particularly observable in regard to the green crops. The potatoes on both sides grew to great perfection, and no distinction could be observed when they were taken up; but the green crops decidedly did best where they had the native guano. The potatoes from either source had an extremely clear skin, and were remarkably fine. Specimens of these exhibited at the Warwickshire Agricultural Society's meeting in September of that year (1870) attracted great notice. When the crops were all removed from the ground the whole garden was sown with vetches, without any further manure, and the result was equal on the two sides. This year the garden was planted over again, but without any fresh manure. As might be expected, the crops were not equal to those of the previous year; but they were very good, and the portion which had previously been fertilised with native guano was quite equal to that where the stable manure had been applied.

The foregoing experiments would seem to show that native guano at £3 10s. per ton is nearly fifty per cent. cheaper than stable manure, the guano not only producing equal crops (if not superior) in the first instance, but holding out equally well in subsequent croppings. In other words, a given sum of money expended in native guano would fertilise nearly twice as great an area as the like sum invested in stable manure. The latter is a much more cumbrous article to apply, and costs proportionately more for carriage and labour. From the foregoing data, it would appear that native guano at £6 per ton would still hold its ground as equally economical with stable manure—perhaps somewhat more so.

Mr. Caswell also conducted an experiment to prove the effect of native guano on grass. For this purpose eight separate acres were measured off in a field. One acre was manured with Peruvian guano, containing 14 per cent. of ammonia, at the rate of five hundredweight per acre, costing £3 5s., the price per ton being £13. The second

acre was treated with half this quantity of Peruvian guano, costing £1 12s. 6d. The third, fourth and fifth acres received respectively half a ton, a quarter of a ton, and an eighth of a ton of native guano, costing respectively £1 15s., 17s. 6d., and 8s. 9d. The sixth acre received stable manure to the extent of eight tons, costing £3. The seventh acre was treated with half this quantity, and the eighth acre with two tons, the values thus being £1 10s. and 15s. This was done about the month of February, 1870. The dry season which followed proved very unpropitious to the experiment, none of the crops doing so well as would otherwise have been the case. But the Peruvian guano answered worst of all, burning up the crops which it was intended to fertilise. The effect of the stable manure appeared to be about equal to that of native guano. No fresh application of manure took place, but when the grass began to grow this year the effect of last year's native guano was distinctly visible, the grass in that part of the field being richer and darker in colour than the rest, and the crop when gathered quite half as much more in quantity as that produced by the stable manure. The two acres manured with Peruvian guano appeared to be entirely unaffected by the previous year's dressing, the virtues of the manure being all exhausted in the first season, although exercised in a manner which failed to be beneficial. In this respect we have met with abundant proof of the difference between native and Peruvian guano. If the former fails to do good at first it is simply because its fertilising properties are not brought into play, and the beneficial effects are sure to be seen ultimately. But Peruvian guano has no power of endurance. For good or ill its efficacy is all put forth in the first season, and there is nothing left for the year following. It is no uncommon circumstance during seasons of drought to find Peruvian guano "burning" the crops by its strong stimulating properties, and doing positive harm. The same is also averred of most artificial manures. As a general result of his experiments, Mr. Caswell states that he would rather have native guano at £3 10s. per ton for the farm or the garden than an equal value of the Peruvian.

If this be the true state of the case, it may be supposed that the British farmer will sooner or later show his appreciation of the native guano. So good and cheap an article ought to be much in demand. On this point we are informed on authority which we have not the slightest reason to disbelieve, but rather every reason to respect, that almost without exception those farmers in the neighbourhood of Leamington who purchased native guano in 1869 not only renewed their orders in 1870, but considerably enlarged them. So great was the demand in 1870 that the Leamington agents were not able to supply much more than a third of the quantity entered on their order-book, and could readily have taken orders to a much greater extent. By courtesy of Messrs. Jacks and Caswell, we examined their order-book for 1870, and found that it fully bore out the statement made to us. One farmer, ordering 100 tons, only received ten. Another ordered 50, and obtained none. One farmer, who bought 10 tons in 1869, ordered 100 tons in 1870, but only received 50. This year he would readily have taken 150 tons, and is now anxious to buy all there is in stock. It might be supposed that this deficiency of supply arose

from a falling off in the manufacture. But so far as we could discover, this was a case in which the embarrassment was caused mainly, if not wholly, by a large and rapid increase in the demand. The Leamington agents are confident that they could sell in their own district ten times as much of the native guano as could be made out of all the Leamington sewage. Farmers have sent their teams long distances for loads of native guano, and their waggons have gone home empty, with the further provocation sometimes of paying toll at the turnpike on their return, seeing that while they had been professedly going for manure the waggons returned without any. The price, it will be observed, in all these cases has been £3 10s. per ton. As for the theory that this popular manure has been "fortified," and is not, therefore, the "native guano" it professes to be, we have the strongest assurance, not only from interested parties, but from others, that this is not the case. Believing, as we do, that the manure is honestly made, we feel that the results are so extraordinary as to justify the degree of attention we are now giving to the subject. There is the more need of doing this, seeing that the Royal Commissioners in their Report on the "A B C" process, dated July, 1870, declare that the manure so obtained "has a very low market value, and cannot repay the cost of manufacture." Such favourable results as were placed before them were disposed of by the Commissioners as being "evidence of the weakest kind." The weather, they said, had interfered with the use of manure, and in regard to the native guano "the whole testimony was thus necessarily that of mere garden beds and flower-pots." Facts, however, are accumulating daily, and as these accumulate we may expect that even Royal Commissioners may receive a little new light. Some of these facts we have already given; but more remain to be narrated, including evidence obtained directly from the farmers themselves.

V.

(*From the 'Standard' of October* 23, 1871.)

Many of our readers may be ready to look upon the circumstance as somewhat remarkable that Leamington should be carrying out a plan of sewage irrigation, while the surrounding district affords such striking evidence of the value of the "A B C" manure. It must, however, be borne in mind that the agreement with the Earl of Warwick was made some time ago, under peculiar circumstances, and before the Native Guano Company came into existence. While the Company have been working out their *ad interim* agreement with the local Board, facts have accumulated of a nature which puts the "A B C" process in a much more favourable light than was possible in its earlier stages. Agricultural experience has been brought to bear upon the subject, in addition to which certain improvements have been effected in the mechanical appliances connected with the preparation of the native

guano, and greater skill has been acquired in the chemical treatment of the sewage. As the case now stands, it is no great wonder that some of the Leamington ratepayers should be found to complain that the local Board have made a bad bargain in their agreement with Lord Warwick. But bearing in mind that which we have already stated with regard to the character of Leamington as a place of fashionable resort, it can readily be understood that at the time when the agreement was made with the Earl, the local Board were only too ready to agree with any one who would take the sewage to the greatest possible distance from the town. The authorities were, if possible, over-anxious for the dispollution of their river, and were not in a mood to calculate the financial part of the question very closely. Leamington, as a wealthy and elegant town, was impatient of the presence of sewage, and was careless as to the idea of getting any profit out of that dangerous commodity. There was also the pressure of legal proceedings to induce decisive measures. Under these circumstances the agreement with the Earl of Warwick was entered into, as cutting the Gordian knot. The Native Guano Company, who proposed to untie the knot rather than to cut it, appeared on the scene after the agreement with Lord Warwick had been entered into, and were simply engaged to treat the sewage until the irrigation farm was ready for its reception.

It may still be suggested that the cost of preparing the native guano is too great to allow a profit, even though the manure be selling at the rate of £3 10*s*. per ton. The Company, on the contrary, assert that their profit is large. To this part of the subject we shall refer at another time, and shall now proceed to cite a further amount of agricultural evidence. A curious exception to the fertilising properties of the native guano deserves to be mentioned, and will probably excite the interest of the naturalist as well as the agriculturist. The statement we are about to make can scarcely appear otherwise than as a very odd one. When Mr. William Siller told one of the farmers in the neighbourhood of Leamington that native guano "would not grow thistles," the assertion was looked upon rather as an amusing piece of enthusiasm than as a real matter of fact. Nevertheless we have seen results which exactly accord with this statement, strange as it may appear, and the phenomenon occurs not merely in respect of thistles, but in the case of weeds generally. We cannot undertake to say that the manure will always produce this effect in the same degree, or that its purifying effect will be distinctly traceable when the quantity used is smaller. But we have seen enough to show that Mr. Sillar's statement is deserving of credit. In one instance part of the pasture near the Leamington sewage works was watered with the "A B C" deposit, and some of the mud was thrown upon part of a bank. When we lately visited the spot that part of the bank which had received the mud was covered with a close fine herbage, entirely free from weeds, while the adjacent part, which had not received the mud, was thickly occupied with nettles and other unprofitable plants. The line of demarcation was remarkably distinct, and we were assured by the owner of the field that the effect was traceable to the cause mentioned. The difference in the grass was also very marked, the verdure where

the mud had been laid being of a particularly deep rich green, an effect which we have frequently mentioned before.

It may be objected that these results accrued from the use of the mud and not of the dry manure. In reply we would advert to what we observed on another farm. Here we saw a field, one part of which had been manured in the ordinary way, and treated with agricultural salt in order to kill the weeds. The other part of the field received no salt, but was sown with white turnips about the middle of August last, native guano being drilled in with the seed at the rate of about six hundredweight to the acre. The former part of the field, where the salt had been applied, was made to bear a crop of swedes. At the time when we went over the ground, somewhat early in the present month, it had already been a matter of remark between the farmer and one of his men, that weeds were abundant where the salt had been applied, while the other part appeared to be entirely free. Walking through the field we observed this to be the case, although our attention was not called to the circumstance at the moment. The turnip portion was nothing but turnips, with luxuriant tops covering the entire space, while the swedes were thickly beset with weeds of various kinds. The reason of native guano being so unfavourable to the growth of weeds may be twofold. In the first place, the manure may be deficient in seeds capable of germination. Such seeds as the sewage may contain may be killed by the chemical treatment and the drying process. In the second place, we may suppose that the native guano is deficient in some element which commonly encourages the growth of weeds, while, on the other hand, its fertilising properties are favourable to the growth of the more useful plants. The extinction of weeds by native guano is the more remarkable, inasmuch as the operation seems to be actually destructive. The farmer first referred to gave it as the result of his experience that the native guano killed the thistles, while it weakened the nettles, and ultimately destroyed both nettles and docks. So far as we could see, the nettles were killed off as surely as the thistles. It is said that where night soil is applied to the ground, nettles generally spring up in abundance. It has also been an accusation against town sewage that where it is applied to grass it encourages the coarser kinds and kills out the finer, though we believe this is chiefly observed, and perhaps only so, where the sewage is applied in excessive quantities. There is, apparently, a good deal of evidence to show that different manures encourage different plants; but it is certainly singular to meet with a manure which nourishes useful vegetation and at the same time kills the weeds. Perhaps native guano would not kill all kinds of weeds or have the same effect on all soils, but certainly in Warwickshire it has helped to fulfil the poet's dream that earth should some day see "her thistly curse repealed."

The effect of the "A B C" mud on the grass of the field first mentioned was highly beneficial. The field immediately adjoining, in the occupation of the same party, afforded further proof. This second field was coated over with guano mud last year during the hot dry weather, after the grass had been burned up by the heat. The first field was treated in a similar manner, and the effect on both was

surprising. The grass grew as high as the rails; and, said the farmer, "It cost me something to get it mowed." A field contiguous to another side of the sewage works, and forming part of another farm, had been treated in a different manner. Mud from the "A B C" Works had, in this instance, been laid out to dry on the field, and when dry was removed. The mud was not laid on until the month of May last; but in the month of September the grass was cut for the third time, leaving a beautiful undergrowth, on which we found some fine Shropshire-down sheep feeding with evident benefit. The state of the field indicated that it was richly nourished, although the mud had been removed as soon as it was dry, and the land had been heavily cropped subsequently. In the case of the two fields where the mud had been applied and allowed to remain, we may further explain that the deposit was applied in an extremely liquid state. One of these fields had received no further application of the mud this year, but the other had received a partial dose. The two fields comprised seven acres, and the total weight of hay obtained this year exceeded twenty tons.

A case which helps to show the comparative value of manures was brought before our notice, and is vouched for by excellent authority. In 1869 three acres of good loamy land were sown with turnips, receiving on one acre thirty loads of stable manure, on another a special manure intended for turnips, while the third acre received a ton of native guano. The stable manure cost £9 15s., if taken at only 6s. 6d. a load. The special manure cost £3 4s., being 8 cwt. at £8 per ton. As the crops came on, the stable manure and the native guano both answered exceedingly well, and the effect seemed very nearly equal; but the special manure produced a very indifferent result. When the crops were taken off, the stable manure yielded 17 loads of turnips per acre, and the native guano 15 loads, while the artificial manure was altogether behind. In the following year (1870) barley was grown on the same field, when the results on the stable manure and native guano portions were apparently equal.

A remarkable instance of turnip growing came under our notice at Warwick Market. A small boy was seen almost staggering under the weight of a huge turnip, which he conveyed to one of the stands in the Corn Exchange, where it was placed on view and attracted much attention. It was a swede turnip, well shaped, and apparently sound. When gathered it weighed 25½ lbs., and when measured it proved equal in girth to the prosperous agriculturist who grew it. We must explain that this turnip grew among mangolds, and in a richly cultivated soil. But it was not an isolated specimen, and there was the fact that it had been raised on ground which had received a moderate dressing of native guano at seed-time. We believe that the proportion was little more than a ton to 3½ acres. The farmer stated that he believed he could find a hundred swedes on this piece which, if put together, would weigh a ton. Many, he said, weighed 18 or 20 lbs. each, and he did not expect that any weighed less than 10 lbs. On another stand in the Corn Exchange were half a dozen swedes grown by means of a celebrated bone manure, costing £6 10s. per ton. These, although fine, were at least one-fourth smaller than the native guano specimen, and we have no reason to suppose that they were

grown on land less highly cultivated than the other. We subsequently visited the field where the big swede was grown, and found a splendid crop, apparently justifying the statement which had been made to us. It was a significant fact that the farmer who grew this crop was storing up a quantity of the native guano, fearing lest he should otherwise be unable to get it when he required it for use. He had also proved its efficacy in growing clover. In several instances we were told of the excellent crops of barley which followed the turnips fertilised with native guano. From a number of farmers we received the unanimous testimony that "native guano" was a good manure. It was not altogether easy at all times to get an expression of opinion, but the opinion when given was always more or less favourable.

In their agreement with the Earl of Warwick, the Leamington Local Board of Health undertake to pump the sewage of the town on to a specified part of his lordship's estate. All the sewage of the town is thus to be delivered for a period of thirty years, his lordship paying the Board the sum of £450 a-year. The Board have also agreed to pump water on to the farm when required, for which they are to receive a certain remuneration. In the meantime the Board are doing their best to reduce the volume of the sewage by excluding as much as possible of the surface water. About one-third of the town already has a separate system for the removal of the surface water, and this plan will be extended as circumstances permit. The number of water-closets in Leamington is large, the authorities doing their utmost for the extirpation of cesspools. The water-works are the property of a private individual, who lets the water to the local Board. A great many houses have wells, so that the works do not represent all the water supply of the town. The water is taken from the Leam, in the vicinity of the Jephson Gardens. After filtration through sand, it is forced by steam power into an elevated reservoir, from which the mains are constantly charged at high pressure, as we stated in a former article. The supply is about a million gallons in three days, or rather more than 330,000 gallons per day. This only amounts to a little over 13 gallons per head, for a population of 25,000; but, as we have already observed, the supply is augmented by the private wells. The dry-weather sewage of the town is stated to be 555,000 gallons in the 24 hours, which is equal to 22 gallons per head, showing at once that the water-works must be largely supplemented. In rainy weather, the flow is greatly augmented.

The whole expense of conveying the sewage to Lord Warwick's farm devolves on the Leamington local Board. More than two miles of 18-inch iron main have been laid, and eight hydrants placed on the farm. The expense of the main and hydrants is £3728, and the laying of the main has cost £963. The dead lift from the pumping station to the farm is 132 feet. The machinery for lifting the sewage consists of a pair of duplicate steam-engines, working alternately, each of 60-horse power, and each capable of lifting 1,500,000 gallons in twelve hours. The cost of the engines, including three double-flue boilers, is £4750. The engine-house, a reservoir to hold 800,000 gallons of sewage, and two cottages, entail an outlay of

£4745, bringing up the total to about £14,000. It is obvious that the working expenses, wear and tear, and interest on capital, will considerably exceed the £450 a year which the local Board will receive from the Earl of Warwick. So far as the Leamington Board are concerned, some help will be received from the two outlying districts of Milverton and Lillington, which will contribute to the expense of the sewage plan in proportion to their rateable value, the sewers of these districts being in communication with the Leamington system. These contributions are expected to amount to £120 or £150 a year. The engines and the works generally are of excellent construction, and there has been no ill-judged stint in the outlay. The engine-house is a tasteful edifice, by no means suggestive of anything relating to town drainage.

In the laying out of the sewage farm on Lord Warwick's estate, the engineering part of the work is under the direction of Mr. W. Clifford, who, we believe, has had considerable experience of irrigation works in India, and who formerly had charge of the Warwick sewage works. The agricultural part of the undertaking is confided to Mr. Tough, whose experience at the Lodge Farm, Barking, points him out as peculiarly qualified for the post. It will be observed that, with the exception of the cast-iron main, all the operations on Lord Warwick's estate are at his Lordship's expense, and are carried out by parties engaged on his Lordship's behalf. The Earl also undertakes all responsibility connected with the use of the sewage from the moment it leaves the hydrants. Hence the Leamington authorities are free from all further fear as to actions at law and Chancery proceedings. We believe, however, that the Native Guano Company are prepared to offer a like guarantee to towns which may be disposed to enter into an agreement for that purpose. As to the risk of nuisance at Lord Warwick's farm, that seems to be carefully guarded against. The only difficulty, if there be any, seems to consist in getting a sufficient area of land ready for the reception of the sewage in due time. On being shown over the farm by Mr. Tough about a fortnight ago, we found that the delivery of the sewage was expected to take place in the course of a few days from that time. But although an abundant area would ultimately be available for the reception of the sewage, a comparatively small portion of the ground was, as yet, prepared. It was, however, part of Mr. Tough's plan to apply the sewage to fallow land during the winter, allowing the manurial elements to remain in the ground until spring, when the sewage would be diverted to market-garden crops, grass land, &c., while the fallow land would be ploughed up and sown. The total area included in the present plan is 331 acres, of which only 80 are as yet completely laid out, in addition to 60 acres of fallow land, which have been simply surface-levelled for the reception of the winter sewage. As rapidly as practicable the whole 331 acres will be duly laid out, after which the farm will get into full working order, subject to such further extension as will be found desirable. A reservoir, to be constructed on the summit of some rising ground, will form a receptacle for the sewage which may pass the hydrants on its course from the pumping station, and the elevation of this reservoir will command an area of 1200 acres.

The proposal to utilise the sewage of 25,000 persons on an area of 331 acres is allowing that the sewage of each 75 of the population will only fertilise an acre. If the sewage of 25,000 persons, when treated on the "A B C" plan, will yield 2000 tons of native guano per annum, we may reckon that the latter system, if applied to the Leamington sewage, would fertilise the whole 1200 acres to which we have referred, and even a much larger space. Again, the dry-weather flow of the Leamington sewage is itself equal to more than 900,000 tons per annum. Taking the ordinary rainfall at 24 inches, this quantity would itself be equal to the rainfall over a space of 376 acres, while the total sewage would of course extend at the same rate over a much larger area. As for the quality of the Leamington sewage, there can be no doubt that it is highly fertilising, and that a maximum effect may be expected from it. If we allow 35 persons to the acre, the area required would be more than 700 acres. Supposing the manurial ingredients of the sewage to be intrinsically worth 10s. per head of the population per annum, this would be the same as applying manure at the rate of £17 10s. per acre. Eleven persons per acre would represent a value of £5 10s. Two thousand tons of native guano, applied to as many acres of land, would be equal to rather more than twelve persons per acre, the cost to the farmer being £3 10s. per acre. Supposing the native guano to be really worth £6 per ton, in comparison with stable manure, the value would be very nearly 10s. per head. But, of course, there is a certain amount of work to be paid for in the production of the native guano, and a portion of the weight consists of added material, which, besides augmenting the weight, also costs something itself. If, therefore, the "A B C" process extracted all that was valuable in the sewage, we should look for even a higher value in the native guano than £6 per ton. We may here remark that fresh sewage contains very little free ammonia, and that the portion which escapes in the effluent water of the "A B C" process does so in a form which is perfectly harmless.

The Leamington Sewage Farm will be conducted on the mixed husbandry system. There will be a large dairy, and accommodation will be provided for 150 head of cattle. Fruits and vegetables will be grown for the Birmingham and Manchester markets. No expense has been spared in providing all the needful appliances, and the farm will unquestionably afford a splendid specimen of sewage irrigation. From the hydrants the sewage is conveyed in stoneware pipes along the head of each field. At suitable intervals the line of stoneware pipes has a species of valve or side-penstock, very simple in its construction, by which the sewage can either be let out or shut off. From these openings the sewage passes on to the ground which it is to fertilise. This plan provides that the sewage shall be invisible, except during the period in which it is flowing over the ground, and soaking through the surface. The pipes themselves are covered with earth, and the sewage is therefore kept as much out of sight as possible. The effect is one of great neatness, and may be expected to reduce the risk of nuisance to a minimum, so far as the mode of distribution is concerned. That the irrigation itself will be a cause of annoyance need not be apprehended, unless the sewage is applied too heavily, which

we need not apprehend will be the case. As soon as the present farm appears in danger of a surfeit there can be no doubt that the area will be enlarged, and it is pretty certain that Mr. Tough will be on his guard in this respect. The manner in which he has laid out the land is itself a proof of his ability to deal with the practical part of the question. The system of carriers varies according to the inclination of the ground, the ridge and furrow plan not being well adapted to a steep gradient. Where the fall is great, the plan is more after the style of the catch-water system. The ground forming the sewage farm is being drained to a depth ranging between four and eight feet. The soil is generally light and pervious, and numerous drainage-wells are provided so that the action of the drains may be carefully watched. The whole of the farm is expected to be ready for the reception of sewage by Midsummer next, and it is calculated that during the winter months the land, or a portion of it, will be able to receive sewage at the rate of 100 persons per acre. It would seem desirable that the "A B C" operators should remain at the old outfall until the farm is really ready for the sewage, so that the land may not be too heavily saturated in the first instance. This precaution did not seem to be contemplated a few days ago, but we confess to some feeling of anxiety as to the destination of the sewage for the next few months. Mr. Clifford and Mr. Tough are doing their best, but the work is heavy, and demands time. Should the sewage farm not work quite satisfactorily at first, we shall expect to find that the defect arises simply from want of time wherein to get ready. Of the ultimate success of Lord Warwick's sewage farm we have scarcely a doubt. But it is clear that the enterprise will not yield any revenue to the town. On the contrary, the ratepayers will have to suffer a certain loss per annum, which they may counterbalance by the consideration that they have got rid of the sewage without creating a nuisance.

VI.

(*From the 'Standard' of October* 31, 1871.)

It will be observed that the facts we have narrated place us in opposition to some of the conclusions arrived at by the Royal Commissioners on the Pollution of Rivers, as given in their Report published last year. Our object is not to raise a controversy, but to elicit truth; and we are willing to acknowledge that, according to the generally-received theory, the Commissioners were, to some extent, justified in appraising the "A B C" manure, or "native guano," at a low amount. We only regret that the Commissioners were not sufficiently philosophical to follow out those results which indicated the operation of a principle not yet fully recognised. It was in this way that they passed by what they called "the testimony of mere garden-beds and flower-pots" and "autumn-sown catch-crops," though, perhaps, if these results had been unfavourable to the "A B C" manure, they would not have been so unceremoniously ignored. While rejecting this kind of "testimony," which, so far as it went, was at least practical and real, the Commissioners proceeded to analyse and to make their estimates, although they acknowledged that their data for reckoning

"the weight and value of the native guano" were not so complete "as might be wished." They even ventured to say, "It was obviously impossible to investigate this part of the process so elaborately as the chemical part, without expending more time than we should have considered ourselves justified in devoting to this one subject." As this was the case at that period, perhaps the subject may now be thought worthy of reconsideration.

It would appear, indeed, that even in that part of the inquiry where the Royal Commissioners were most at home they fell into some degree of error. The Commissioners charged the "A B C" Company with an enormous dilution of the effluent water at the Leamington Sewage Works, so that this sewage was made to appear as if purified to a greater degree than was really the case. This conclusion was based on the circumstance that the effluent water contained considerably less chlorine than existed in the original sewage, whereas—so the Commissioners stated—the "A B C" mixture exerted no influence whatever on the chlorine. Dilution, therefore, was the only mode of accounting for the reduced proportion of chlorine in the effluent water as compared with the sewage. The admixture was estimated in some cases to be as much as fourfold. It so happens that an independent inquiry into the "A B C" process has lately been conducted by an eminent and well-known chemist, who finds that this process does actually reduce the amount of chlorine, whatever may be the preconceived opinion of chemists generally, and whatever may have been the experiments of the Royal Commissioners. The particular chemist to whom we now refer adopted a very interesting mode of investigation. He collected specimens of the London sewage as it was flowing from the main into the tank, at the Lodge Farm, Barking. He also took a sample of the effluent water from the same farm, which, as the public are aware, has been for some time irrigated with the London sewage. The sewage itself, which was thick and emitting a foul smell, was mixed with the "A B C" compound in the proportion of 2 drachms to 10,000 grains. After agitation the mixture was left to settle. In twelve hours, as the supernatant liquid was not quite clear, it was filtered through porous paper, which had the effect of rendering it perfectly bright. It was also inodorous and tasteless. The effluent water from the Lodge Farm was likewise bright, and without taste or odour. The sewage, when filtered by itself without previous treatment, could not be obtained clear and bright. The filtered sewage untreated contained 7·27 grains of chlorine per gallon. But the clear water—or effluent, as we may term it—obtained after mixing the sewage with the "A B C," contained only 4·08 grains of chlorine, thus showing a reduction of 3·19 grains per gallon, or about 44 per cent. How much "dilution" this indicates can, doubtless, be calculated by the Royal Commissioners; but it is equally certain that there was no dilution whatever, the result being solely due to the action of the "A B C" ingredients. On the other hand, the irrigation effluent contained 6·92 grains of chlorine per gallon, or a very slight reduction as compared with the filtered sewage. The albumenoid organic matter in the filtered sewage was 0·09 grains per gallon. In the irrigation effluent this was 0·08 grains, but in the "A B C" effluent it was only 0·03 grains. The volatile residue in the irrigation effluent was 9·39 grains per gallon. In the "A B C" it was reduced to 3·30 grains, almost identical with the quantity shown by a sample of Lambeth drinking-water. The nitrates and nitrites were fully six times as much in the irrigation

effluent as in the "A B C." Accordingly, the indications of "previous sewage contamination" were sixfold in the one case to what they were in the other, although the origin was the same. The ammonia in the irrigation effluent was much less than in the "A B C." On this point we may observe it is somewhat remarkable to find the filtered sewage containing only 1·70 grains of ammonia per gallon. This is the more peculiar, inasmuch as the sewage is described as "thick and foul smelling." In reality it must have been dilute, the proportion of ammonia being only about one-third of that usually obtained in dry weather. The dilution is also indicated by the fact that the other constituents of the sewage are diminished in the same proportion. It is quite possible that if the ammonia had been present in its normal quantity, the "A B C" mixture would have produced a better effect. As it is, in this case we find the irrigation effluent having only 0·02 grains of ammonia, while the "A B C" has 1·68. The chemist who conducted the analysis observes:—"In justice to the process, I must state that my experiments were tried on only a gallon of sewage, and I can easily imagine that, when operations are carried out on a large scale, it will be easy to effect a still greater purification of the effluent water." With regard to the removal of ammonia by the irrigation process, it must be remembered that nitrates and nitrites are apt to be of large amount in the irrigation effluent. Such has been the case at Romford, for instance. The Lodge Farm, moreover, is scarcely a correct example of sewage irrigation. The flow of sewage there is not continuous, but is checked or admitted at pleasure, just as the farm may happen to require it. The necessities of a town require that the sewage shall be taken at all times, let the season or weather be what it may.

We have mentioned the great reduction effected by the "A B C" compound in the amount of volatile solid residue. This ingredient practically represents organic matter, and it is singular that the "A B C" should here transcend the irrigation system, the irrigation effluent containing nearly three times as much volatile solid matter as the "A B C." The albumenoid matter, which is especially deleterious to the purity of a river, is also more effectually removed in this case by the "A B C" process than by irrigation, the effluent from the farm having more than twice the quantity of albumenoid matter than the clear water obtained by the other method. In the fixed solid residue the irrigation process has somewhat the advantage, but not so as to compensate for the difference in the case of the volatile matter. Thus the total solid residue of the irrigation effluent is 40·89 grains per gallon, and of the "A B C" effluent 38·38 grains, the Lambeth water showing 20·38 grains. In decomposing organic matter the irrigation effluent has a slight superiority, having 0·09 grains per gallon as against 0·13. But the chemical authority who furnishes the analysis states in his Report—that Report being quite independent of the Native Guano Company—"These figures show that the 'A B C' process has effected a very fair amount of purification. In the important matters of volatile residue, chlorine, and albumenoid organic matter, it shows a decided superiority over the irrigation process." It is not advised that the "A B C" effluent should be cast into a river near the source of a drinking supply; but the chemist in question says in his Report, "A water which is as bright and colourless as ordinary spring water, which is sufficiently free from colour, taste and odour to be taken into the mouth and swallowed without repugnance. which does not putrefy or develope unpleasant smell on standing for several days in a warm

room, and which does not deposit any sediment, certainly cannot be considered an unfit water to throw into a river."

The ammonia question now demands our consideration. There is reason to believe that irrigation does not remove so much of the ammonia as was at one time claimed for it.* A great part of the nitrogen flows away in an oxydised condition—harmless, it is true, but still lost to vegetation. The "A B C" process retains apparently still less of the ammonia, but here also it is stated that the ammonia which is lost goes away in a harmless condition, chiefly as a sulphate. Granting that the "A B C" manure is possessed of comparatively little ammonia, there would seem to be a difficulty in accounting for its success as a fertiliser. This brings us to a most interesting subject of inquiry. In the first place, the action of pure ammonia is altogether unknown. The illustrious Liebig, referring to the analysis of the soils in different countries, computes that "the greater number of our cultivated fields" contain within a depth of ten inches "much more" than 10,000lb. of ammonia in the space of a hectare, eqnal to two acres and a half. In fact, Liebig seems to allow that even a single acre may contain this enormous quantity. Why, then, are our agriculturists so anxious to add ammonia to their fields? It may well be argued that an acre of ground which contains in its upper ten inches of soil 10,000lb of ammonia or nitrogen, cannot have its fertility increased two-fold by the mere addition of 30lb. to 60lb. of ammonia. As in such a soil there was no want of nitrogen, the cause of the increased fertility must be sought for in something else. Liebig remarks, "The most recent observations on the comportment of the soil towards the food of plants show how slight is the knowledge we possess of their mode of nourishment, and of the part which the soil, by its physical condition, plays in it." The great desideratum appears to consist in a solvent for the earthy phosphates. "We know of no other way," says Liebig, "in which the earthy phosphates are dispersed through the soil than by means of carbonic acid water." It would seem that one of the chief effects of humus, or the decaying remains of plants in soils or in

* On this important point we make the following extract from an article on "Sewage Irrigation at the Lodge Farm," in the "Standard" of November 9, 1871:—"The report of Mr. Henry J. Morgan, addressed to Mr. R. A. Heath, the chairman of the Metropolis Sewage and Essex Reclamation Company, giving an account of a year's operations at the Lodge Farm, Barking, has just been published. The year in question ended on August 31, 1871, but the transmission of the report is stated to have been delayed in order to include the analyses of Dr. Frankland. These analyses refer, in the first place, to the sewage as taken from one of the wooden carriers on the farm; and, in the second place, to the effluent water as obtained three hours afterwards from the outfall. It may be presumed that the latter represents the effect produced on the sewage in its passage over and through the soil intervening between the two points. The analyses are expressed in parts per 100,000. The suspended matter in the sewage was 10·84, and of the effluent water we are told that it contained 'few suspended parts.' The total solid matter in solution was 96·1 in the sewage and 91·3 in the effluent. The organic carbon was reduced from 2·583 to 0·676; the organic nitrogen, from 1·752 to 0·198; and the ammonia, from 5·450 to 0·005. The elimination of ammonia would therefore appear to be practically perfect, and so far it might be argued that sewage, like many other manures, was effective as a fertiliser, because containing so much ammonia. But on looking further we find that while nitrogen, in the form of nitrates and nitrites, is absent from the sewage, it is present in the effluent in that form to the extent of 4·143. This process is rendered still more apparent by the fact that while the total combined nitrogen contained in the sewage is given as 6·240, as much as 4·345 is found passing off in the effluent, only 1·895 parts being left in the soil."

manures, consists in the formation of carbonic acid, with which the air and water in the ground are enriched. The importance of this process is shown by the following remarks of Liebig:—"The most abundant application of earthy phosphates in coarse powder can in its effects bear no comparison with a much smaller quantity which, in an infinite state of division, is dispersed through every portion of the soil. A rootlet requires, at the spot where it touches the soil, a most minute amount of food, but it is necessary to its functions and its very existence that this minimum be found exactly at this spot." The same authority says, "By its decomposition in the soil, humus forms a source of carbonic acid, by which the fixed elements of food are rendered soluble and capable of being distributed in all directions."

It would, therefore, appear that if the "A B C" manure be deficient in ammonia, it may nevertheless have the power of generating carbonic acid, after the manner of the original humus, and in that case it would emulate the action of a manure known to be rich in ammonia. On this principle it would seem that two manures, very different in their composition, would—in the language of Liebig—"exert an equally favourable influence on the growth of plants." Liebig himself distinctly argues that as our cultivated plants share equally with the uncultivated in the ammonia and nitric acid of the air, the rain, and the dew, it therefore follows "that the agriculturist will seldom have to seek the reason of his poor crops in a deficiency of ammonia or nitrogenised food alone, and that he must first of all direct his attention to certain other conditions in order to improve his harvest." "Nitrogen," says Liebig, "produces by itself no effect when the conditions are wanting which render it active." It may even be the fact that the native guano supplies some of the conditions which render the ammonia of the soil active and beneficial. A somewhat analogous case presents itself in the application of water to the soil. Referring to the small amount of ammonia in the water of the Thames, Liebig observes, "By irrigation, the Thames water would undoubtedly produce a considerable increase in the crops of hay on many meadows, but certainly not by its ammonia."

It may be said that we have proved too much, and that we are showing ammonia to be useless as a manure. Upon the whole, we think that the advocates of ammonia must do as we are doing, and rely on results. Apart from experience, it seems as difficult to prove the virtues of Peruvian guano as of "A B C" manure. Liebig, in one place, endeavours to account for the observed effects of the soluble salts of ammonia by saying that they possess "the same solvent property" as carbonic acid water. Accordingly they render the earthy phosphates soluble, so that in this respect they substitute their power for that of the organic matters, "and thus exert an equally favourable influence on the growth of plants." The same idea is expressed in the following sentence, "Like carbonic acid, the sulphate, as well as other soluble salts of ammonia, possesses the property of rendering the earthy phosphates soluble in water." We also find the Baron making such a statement as this: "It is of great importance for agriculturists to know that the supply of ammonia is unnecessary for most of our cultivated plants, and that it may be even superfluous if only the soil contain a sufficient supply of the mineral food of plants, when the ammonia required for their development will be furnished by the atmosphere." Hence it follows, "It is also of importance to know that the rule usually adopted in France and Germany, of estimating the value of a manure according to the amount of its nitrogen, is quite fallacious, and that its value does not

stand in proportion to its nitrogen." In regard to the action of ammoniacal manures it is further stated, "It has been abundantly proved by facts that the action of the salts of ammonia is no way proportional to the amount of nitrogen in them." Another assertion which may surprise some persons runs thus: "It is quite certain that a soil from which a poor crop of corn has been reaped will not be made to yield a greater quantity even by the most abundant application of ammonia." Still, as a general rule, the good effects of a manure which is rich in ammonia cannot be denied. To account for this fact Liebig says, "The explanation which can be offered of the effect of nitrogenised manures and their advantages in certain cases is, that the agriculturist furnishes to certain plants, having a scanty supply of leaves and roots and a short existence, in quantity as manure, the nitrogen which they have not time to absorb from natural sources."

The great practical measure on which Liebig relies is one which gives to his opinions peculiar weight on such a subject as that to which these articles refer. "There exists a recipe," he says, "for ensuring the fertility of our fields and the permanence of their crops, and which, if properly and consistently applied, will prove more remunerative than all the expedients that have ever before been resorted to by agriculturists." The Baron's prescription is this: "Every farmer who takes a sack of corn or a hundredweight of rape, turnips, potatoes, &c., to the town, ought, like the Chinese coolie, to carry back with him from the town an equal (or, if possible, a larger) quantity of the mineral constituents of the produce sold, and restore them to the field from whence they have been taken." To accomplish this purpose Baron Liebig proposes that all the proprietors of the soil in every great country should form a society for the establishment of reservoirs where the excreta of men and animals might be collected and converted into a portable form. Bones. soot, ashes, lixiviated and unlixiviated, the blood of animals, and offal and refuse of all kinds, are to be collected together in these establishments, and prepared for transport by the society's own officials. It will be observed that this is not sewage irrigation. The plan proposed is that which chemists generally denounce as impracticable, and which would be sure to fall under the disfavour of the Royal Commissioners on the Pollution of Rivers. All the refuse of a town, liquid and solid, is to be collected into reservoirs, and "converted into a portable form" for use as a manure. Both solids and liquids are to be dealt with. So far the "A B C" process agrees with the plan proposed by Liebig. It has its reservoirs, where the excreta of men and animals are collected, and where a precipitate is obtained which, being dried, is offered for sale in "a portable form." Liebig's plan does not exclude sewers, for he says, "To render the execution of a plan of this kind possible, Government and the police authorities should take measures to insure the proper construction of latrines and sewers in towns to guard against the waste of the night soil, &c."

The necessity of utilising the sewage of towns is insisted upon by Liebig in the strongest possible terms. He says, "Agriculturists must not depend on guano." This article is continually getting dearer, and if it were not likely ultimately to fail, it were yet unwise to rely on a foreign manure for the sustentation of our fields. Even if Peruvian guano could be obtained in perpetuity, it would not suffice to maintain the fertility of the ground. It is deficient in potash, and on soils poor in this ingredient (as in the case of soils with much lime or sand) the effect of guano, after a certain time, perceptibly diminishes, its efficiency being restored by the addition of wood

ashes, rich in potash. Liebig says, "The excrements of man contain the *full complement* of mineral elements, removed in grain and flesh; but in guano there is wanting a certain quality of potash to replace fully these ash constituents." Unless we return to the soil that which we take from it, the great chemist to whom we have thus extensively referred distinctly predicts the ultimate exhaustion of our fields, and the ruin of our agriculture —results which befel many of the nations of antiquity.

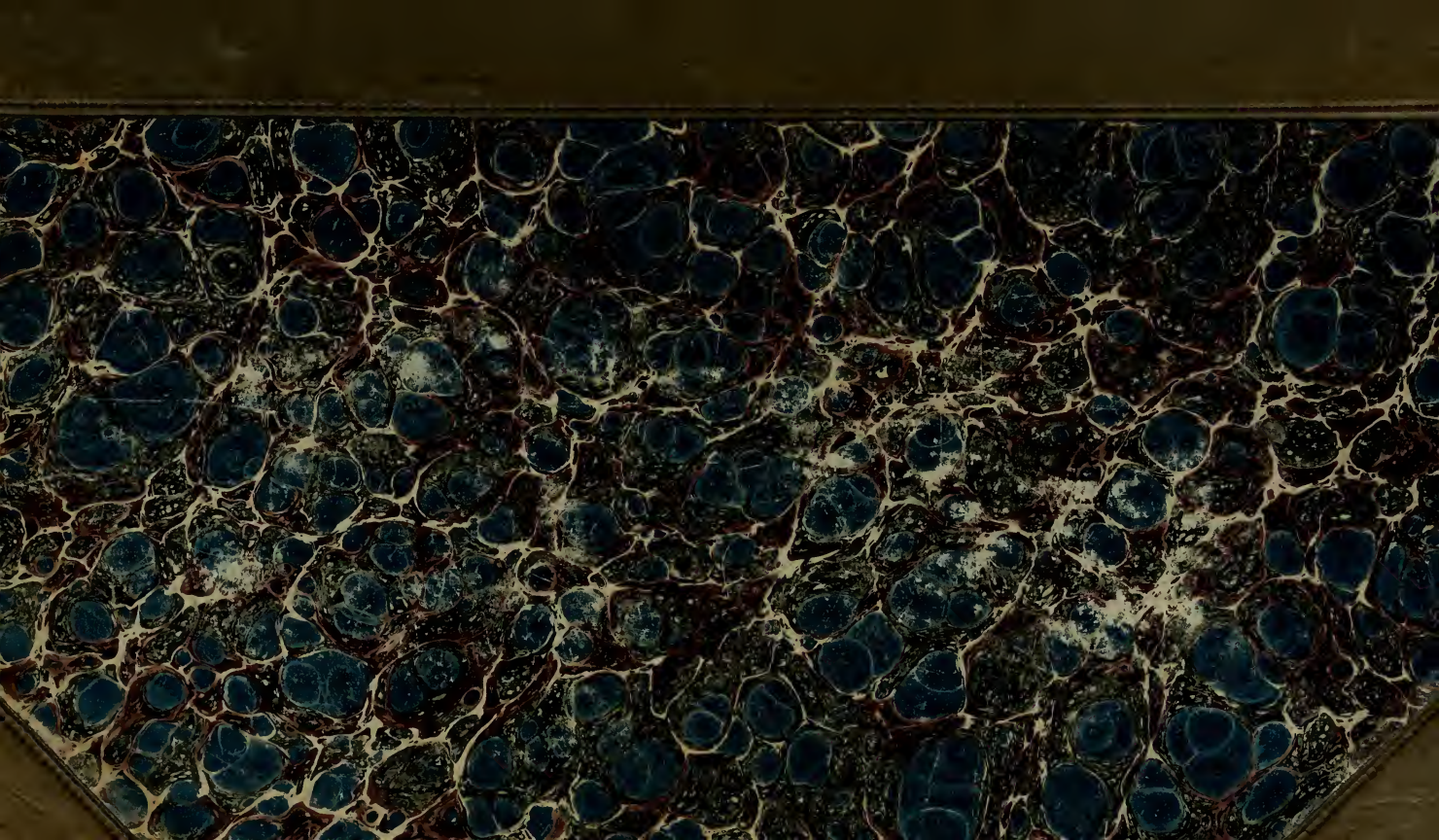
How, then, can we best proceed to replenish the soil? Sewage irrigation is a certain method, but a costly one; and in some cases the cost is so great as to be really prohibitory. Undoubtedly there are localities where sewage irrigation is practicable, and where it ought to yield a profitable return. But towns shrink from the expense, and the farmers are in much the same predicament. The Earl of Warwick, as we have shown, is laying out land in a very perfect and costly manner for the reception of sewage; but his lordship only pays the Leamington authorities at the yearly rate of fourpence halfpenny per head of the population, and the ratepayers will have to make up a deficiency of at least £700 a-year. This is better than wasting the sewage and creating a nuisance. At Tunbridge Wells there is, perhaps, a still greater pecuniary loss, although the authorities there have farms of their own. Land near towns is apt to be dear. Cheap land lies farther off, and if such be obtained there is then the expense of constructing a main sewer for so great a distance. It will also be found at Tunbridge Wells, at Banbury, and elsewhere, that the area of land taken is insufficient. If there be no other plan available, these difficulties must be grappled with and overcome as they best may. But in the meantime there is evidently great reason to believe in the excellence of another mode. There are, indeed, other precipitating methods besides the "A B C." But precipitation is only part of the question. The mode of drying the deposit, the prevention of nuisance in the process, the preservation of the valuable ingredients, and the commercial economy of the undertaking, are all so many points of essential importance. On the last-named point some striking figures were lately given in an article in these columns referring to the Crossness Works. A pretty good answer is also afforded by the present price of the Company's shares.

Altogether we venture to think that the facts which we have laid before the public are sufficient to establish for the "native guano" enterprise a great degree of merit. It should not be forgotten, in dealing with the agricultural part of this question, that there was a time, only thirty years ago or less, when Peruvian guano—then first introduced into this country—was looked upon with doubt. Liebig tells us that when the first vessel loaded with guano arrived at Liverpool numerous experiments were made with the new manure, which proved failures; and agriculturists were not agreed about its utility until they had practically tested its use. We have ourselves found instances in the course of the present inquiry in which Peruvian guano had not only failed to do good, but had actually done harm. We never found a case in which the native guano had exercised an injurious effect, but many in which it had been of excellent service. The native guano is not only presented in a portable and inoffensive form, but it has the advantage of economising the sewage so as to fertilise a far greater area than is possible when the raw sewage is applied direct to the ground. Granting that certain of the matters still held in solution escape in the effluent water, there is the possibility of saving these matters by discharging

the effluent water over the land—a process which would give no offence to neighbouring dwellings. The operation by which the manure is prepared has undergone modifications from time to time, and there seems to be no reason why any disagreeable gases or vapours should arise to annoy the neighbourhood from this source. The effluent water is also such that it may fairly go into any river, though as a matter of precaution the point of discharge should not be near the source of a drinking supply. As for the manure itself and its real value to the agriculturist, on this point there need be no doubt, and we think the facts we have laid before the reader will be ample for the satisfaction of every candid mind. At all events, there is an abundant market for the native guano, and we may expect the demand to increase as the practical effects of the manure become more generally known. The promise of the "A B C" process is indeed bright, and the public are directly interested in its fulfilment. We trust that the success of the undertaking will soon be such as to admit of no controversy, except on purely theoretical grounds. The enterprise has already nearly reached this stage, and the discouragements which at one time presented themselves have, perhaps, only served to bring about a greater degree of efficiency in the practical working out of the original idea.

INDEX.

PAGE

"A B C" Ingredients 12
,, Process, description of 12, 13
Ammonia as affected by Irrigation 49
,, in the soil 49
Barking Irrigation Farm 31, 32, 47, 48
Bolton Sewage 23, 24
,, Sewage Works 24, 25, 26
Chlorine affected by the "A B C" Process 7, 47
Comparison between different systems 27, 28, 31, 32, 33, 36, 45, 47, 48, 49, 52
Cost of "A B C" Works 16, 25, 29
,, Irrigation Works 28, 43, 44
Crossness Sewage Works 9, 10, 11, 12, 13, 14, 15, 16
Earl of Warwick's agreement with Leamington ... 34, 35, 39, 40
Economy of Utilisation of Sewage 31, 32, 33, 45, 51, 52
Effluent from "A B C" Process 47, 48, 49, 53
,, Irrigation Farm 47, 48, 49
Fortification of Native Guano 7, 17, 18
Irrigation 5, 22, 27, 28, 31, 32, 43, 44, 45, 46, 47, 48
Leamington "A B C" Works 33, 34, 35, 36
,, Irrigation Works 34, 35, 43, 44, 45
Leeds Sewage 29, 30
,, Sewage Works 29, 30, 31
Liebig, Baron, on the action of manures 49, 50, 51, 52
London Sewage 9, 10
Moule's Earth System 32, 33
Native Guano, chemical value of 49, 50
,, demand for 7, 38, 39
,, effects of 7, 18, 19, 20, 21, 22, 37, 38, 40, 41, 42
Nitrates and nitrites 48, 49
Peruvian Guano 37, 38, 50, 52
Previous sewage contamination 48
Rivers Pollution Commissioners 6, 29, 35, 36, 39, 46, 47
Tunbridge Wells Irrigation Farms 27, 28
Value of Sewage 32, 45

E. NEWMAN, PRINTER, DEVONSHIRE STREET, BISHOPSGATE, LONDON.